Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

MARCH, 1948

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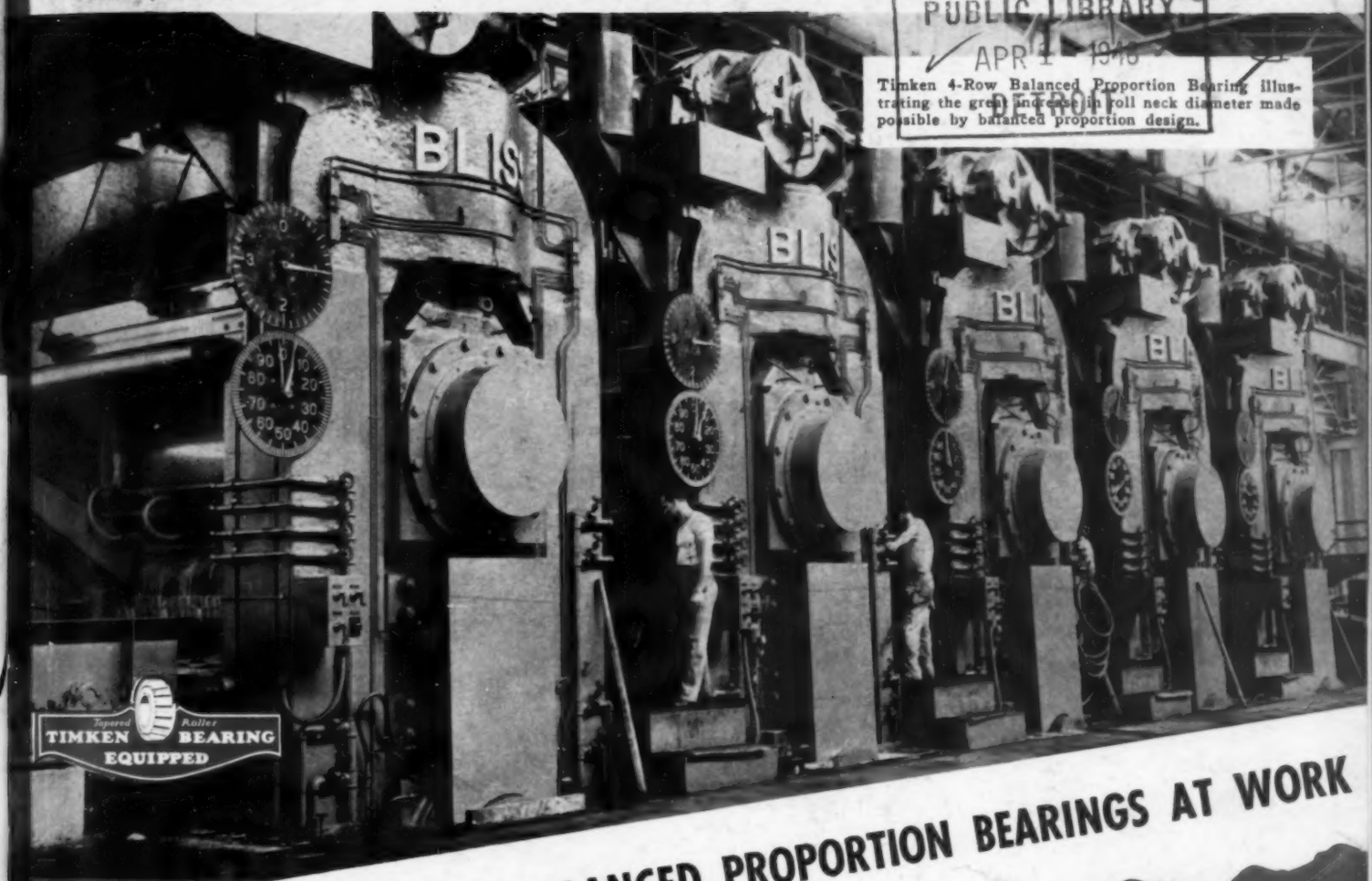


Timken 4-Row Balanced Proportion Bearing illustrating the great increase in roll neck diameter made possible by balanced proportion design.

TIMKEN® BALANCED PROPORTION BEARINGS AT WORK

This 26" and 55" x 80" 4-high 5-stand hot strip mill built by E. W. Bliss Company, Salem, Ohio, for Reynolds Metals Company, McCook Plant, Cicero, Illinois, is one of the largest and most modern in the country. It is completely equipped with Timken Bearings on all back-up and work rolls, screwdowns and drives.

The mill was installed in 1943 to roll aluminum strip and is another outstanding example of the efficiency, availability, simplicity, and economy of Timken Balanced Proportion Roll Neck Bearings.

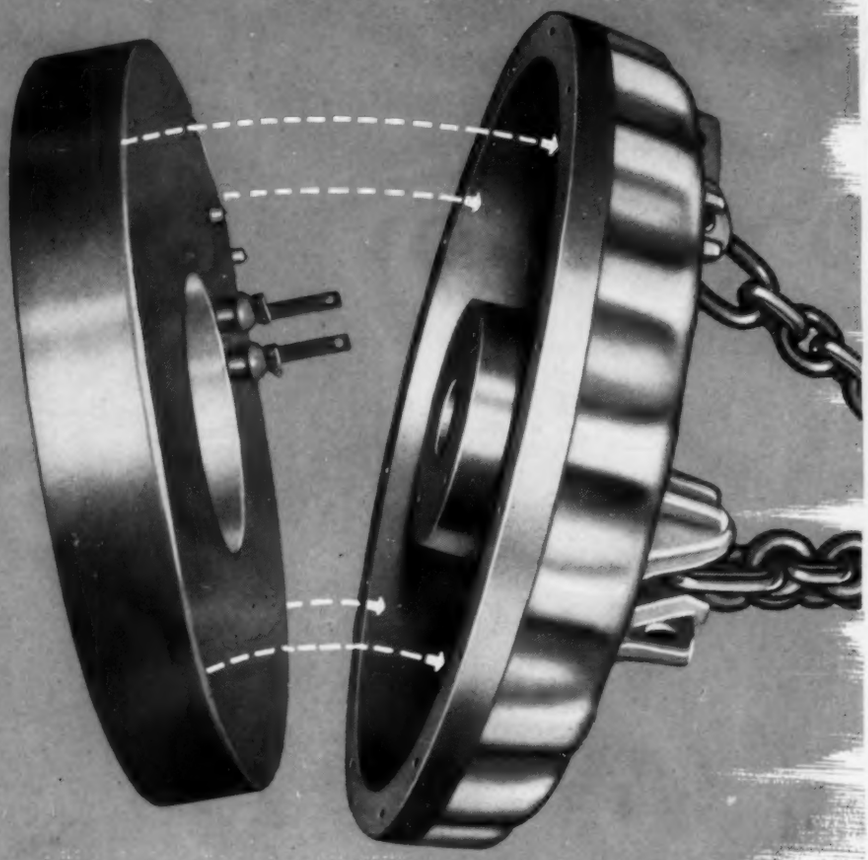
There now is no need to deny yourself the advantages of roller bearings in existing or new mills. Timken Balanced Proportion Bearings make possible 50% to 60% increased roll neck strength and show load ratings up to 40% higher than previous designs of tapered roller bearings, thereby assuring greater mill and bearing rigidity and higher rolling precision. For specific information consult the mill builder or our engineers. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address "TIMROSCO".

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
ROLL NECK BEARINGS

NOT JUST A BALL — NOT JUST A ROLLER — THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION

Now! **New CAPSULE-COIL Magnet Construction**

FOR LONGER LIFE AND EASY ON-THE-JOB COIL REPLACEMENT



Now! **New anti-wear features prolong chain life**

Cutler-Hammer Supermagnets now embody a new welded, steel-sheathed CAPSULE-COIL sealed against moisture. With this new design plus removable pole shoes *YOU CAN REPLACE A COIL* easily, quickly and with a minimum of "time-out." For coil repairs, only the CAPSULE-COIL need be returned to the manufacturer. With a spare CAPSULE-COIL replacement, your Supermagnet goes back to work at once.

Also NEW, a radically different chain suspension, replacing the conventional top link with a new "non-twist," anti-wear yoke. This, plus redesigned, streamlined body lugs, materially eliminates trouble at the spots where chain usually wears out.

These major Cutler-Hammer advances match other Supermagnet features . . . high permeability steel spool, part of magnetic path . . . strap copper windings insulated by impregnated asbestos ribbon . . . high dielectric, bonded, mica discs between coil layers and CAPSULE case . . . an improved impregnation and insulating process. These superiorities—the result of 50 years of engineering leadership—merit your selection of "Cutler-Hammer" for your next magnet requirement . . . CUTLER-HAMMER, Inc., 1257 St. Paul Ave., Milwaukee 1, Wisconsin.

CUTLER-HAMMER
SUPERMAGNETS
C-H

IRON AND STEEL ENGINEER, published monthly by Association of Iron and Steel Engineers, entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress March 3, 1879. $7.50 per year in United States, $8.25 Canada, $10.00 foreign countries. Volume 25, No. 3.

TECHNOLOGY DEPARTMENT

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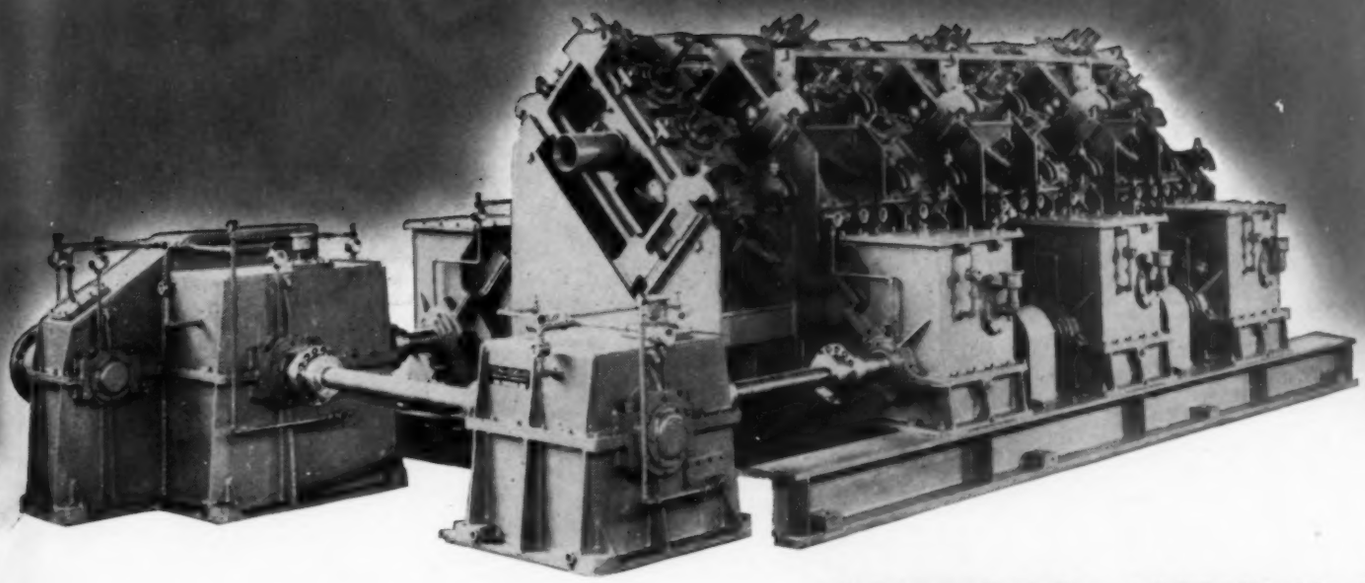
AS THE RECORD STANDS



*AETNA-STANDARD *has shipped more* SIZING MILLS *than any other Company*

DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries

Aetna-Standard's accredited leadership is evidenced by installations made, orders being processed and those being received. With Aetna's knack of ingrained, practical know-how, and the versatility of its forward-looking engineering, you can achieve money-making efficiency with low maintenance cost by relying upon Aetna sizing mills . . . as do other industry leaders. The two types of sizing mills, closed housing and overhung rolls, are built for sizing butt weld, lap weld or seamless tubes from 3/8" to 24" O.D. As specialists, we combine experience, facilities, and knowledge for one purpose — building the most efficient mill equipment for your use. Ask for sizing mill data based upon your specific requirements.

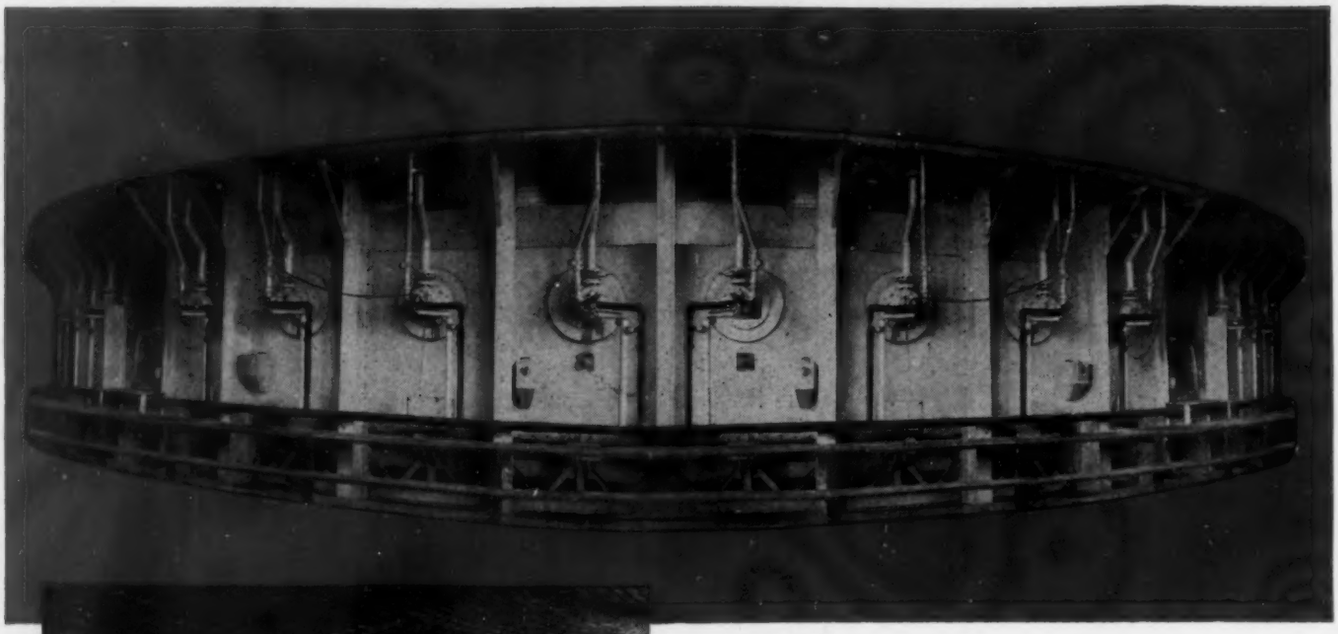
THE AETNA-STANDARD ENGINEERING COMPANY

YOUNGSTOWN, OHIO

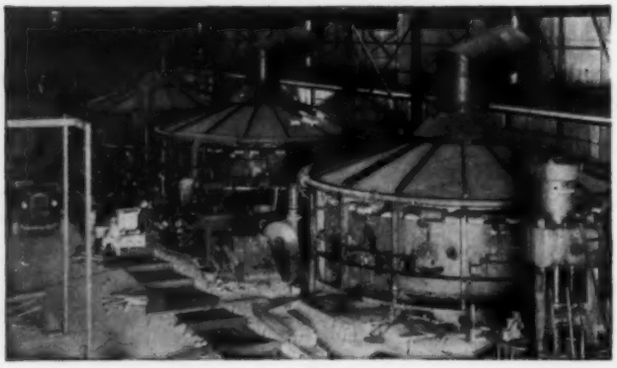
ASSOCIATED COMPANIES:

HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND

AETNA-STANDARD ENGINEERING COMPANY, LTD., TORONTO, ONTARIO, CANADA



Inside view after five years' service.



SALEM ROTARY FURNACES

. . . offer automatic billet charging into the furnace on a predetermined and selective spacing.

Furnace discharge is controlled by an operator whose only function is to direct the peel at timely intervals to tie in with the mill, press or hammer requirements.

Costly labor is greatly reduced — a multiple installation of furnaces requires only one operator per furnace, regardless of rated capacity, and *one furnace tender for as many as four (4) units.*

SALEM ENGINEERING CO. • SALEM, OHIO
SOUTHWEST OFFICE • FORT WORTH, TEXAS
SALEM ENGINEERING CO. (Canada) Ltd., TORONTO
SALEM ENGINEERING CO. • SHEFFIELD, ENGLAND

SALEM

ALL OFFICES STAFFED FOR . . . ENGINEERING, CONSTRUCTION and OPERATION

R-5

Salem Builds

CIRCULAR SOAKING PITS
ROTARY HEARTH FURNACES
CONTINUOUS BUTT-WELD FURNACES
CAR BOTTOM FURNACES
FORGE FURNACES
HEAT TREATING FURNACES
NEEDLE METALLIC RECUPERATORS
AIR RECIRCULATING FURNACES
GAS ATMOSPHERE FURNACES
MECHANICAL EQUIPMENT FOR CHARGING AND DISCHARGING MATERIAL FROM FURNACES

HYDRAULIC PRESSES

AUTOMATIC
FULL-HYDRAULIC
SELF-CONTAINED

FROM 200 TONS UP
TO THE HIGHEST
CAPACITIES

SINGLE- OR DOUBLE-
ACTING WITH OPPOSING RAMS

AUTOMATIC
ELECTRONIC CONTROLS

ACCURATE ADJUSTMENT
AND STEPLESS VARIATION
OF STROKE
PRESSING SPEED
ULTIMATE PRESSURE
AND PERIOD OF DWELLING

AUTOMATIC FEED
FOR POWDER
AND
PRE-FORMED PIECES

AUTOMATIC
PUSH-OUT DEVICE

ECONOMIC
IN MASS PRODUCTION

OF INTRICATE PARTS OF
HIGH STRENGTH, HARD-
NESS AND DESIRED DENSITY,
TO CLOSE TOLERANCES,
AND WITH LITTLE OR NO
SUBSEQUENT MACHINING
AND FINISHING OPERATIONS

AT RIGHT: SELF-CONTAINED, OIL-HYDRAULIC SINGLE-ACTION PRESS OF 500 TONS CAPACITY, DESIGNED FOR THE DOUBLE FUNCTION OF PRE-PRESSING AND COINING POWDERED METAL.

AT THE AMERICAN ELECTRO METAL CORP.
YONKERS, N. Y.

HYDROPRESS · INC.

ENGINEERS *CONTRACTORS*

HYDRAULIC PRESSES · ROLLING MILLS · PUMPS
ACCUMULATORS · DIE CASTING MACHINES

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DETROIT SAN FRANCISCO SEATTLE WASHINGTON, D. C.

"ROUND IRON FOR SHIP BOLTS

AND OTHER USES"

Water wheel driven tilt hammer, "tail helve" type, in an early Pennsylvania forge—Photo by courtesy of Mr. John Knox

Clipper ships needed bolts—big bolts and long bolts. To make them and other round rods, early ironmasters harnessed water power to tilt hammers, turning the billet in a grooved anvil while it was being forged into rods.

In 1810, Rentgen was granted the first United States patent for "rolling iron round, for ships' bolts and other uses." By 1870 a Bedson continuous wire rod mill, first of its kind in this country, was in operation in Massachusetts.

In the same year, Pittsburgh Rolls began serving the iron and steel industry by supplying rolls that produce at *less cost per ton of steel rolled.*

PITTSBURGH ROLLS Division of Blaw-Knox Company
PITTSBURGH 1, PENNSYLVANIA

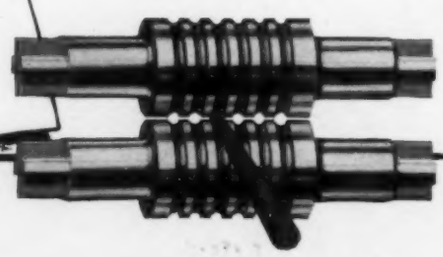
ROLLS FOR RODS AND ROUNDS

Roughing stands: Phoenix "A" Alloy Steel, Phoenix Metal, or Pittsburgh Grade 25 Grain Type.

Intermediate stands: Harder grades of Phoenix Metal or Phoenix "K" Grain Alloy Iron, except where a tougher, stronger roll is required in which case Pittsburgh Grade 25 Grain Type is suitable.

Leader and Finishing stands: Chilled Iron, an excellent material which imparts a good finish.

Final stands for larger rounds: Phoenix Metal or Phoenix "K" Grain Alloy Iron, because of deeper penetration of hardness and additional strength.

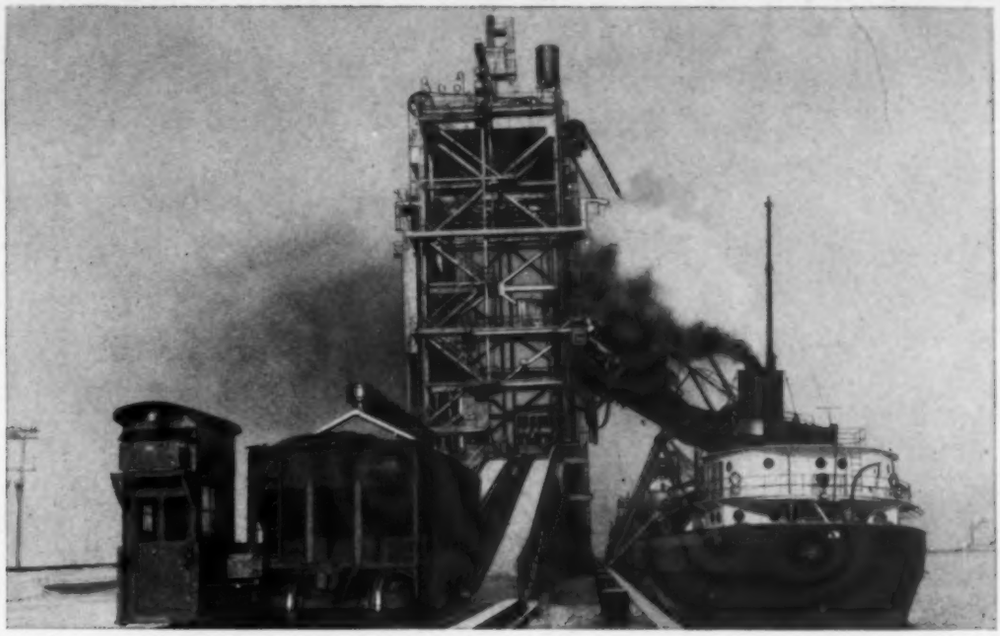


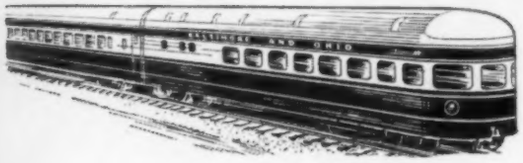
SEND for Catalog No. 2090 giving recommended rolls for all types of mills.

P.R.W

PITTSBURGH ROLLS

The Heyl & Patterson new electrically-operated Car-a-Minute Coal Car Dumper at Lorain, Ohio.





Take the B&O as an illustration of how Heyl + Patterson DESIGNS, BUILDS AND ERECTS HEAVY BULK MATERIALS HANDLING EQUIPMENT

If you have a problem in dock and coal handling facilities, you'll want to see the Baltimore & Ohio's new $4,000,000 Coal Dock at Lorain, Ohio.

You'll see one of the most modern dock and coal handling facilities in the world when you inspect (through the courtesy of B & O) this new, large-capacity, modern, rail-to-water coal transfer plant.

Playing an important part in the successful operation of this modern Coal Dock is a Heyl and Patterson High-Lift Coal Car Dumper. It is capable of discharging Coal Cars up to 120-ton capacity into the hold of a vessel. It can dump cars at the rate of one-per minute.

See for yourself. Visit Lorain . . . or ask a Heyl and Patterson Engineer to consult with you on Coal Car Dumping or any kind of Heavy Bulk Materials Handling Equipment problem.

Ore Bridges
Railroad Car Dumpers
High Lift-Turnover-Rotary
Coal & Coke Handling Equipment
Boat Loaders & Unloaders
Pig Iron Casting Machines
Rotary Mine Car Dumpers
Coal Crushers
Coal Storage Bridges
Car Hauls & Boat Movers
Bradford Breakers
Refuse Disposal Cars
Thorsten Coal Samplers

Heyl + Patterson, Inc.

SINCE 1887, BULK MATERIALS HANDLING EQUIPMENT . . . . . ALL THE WAY FROM DESIGN TO ERECTION.

55 WATER STREET · PITTSBURGH 22, PA.

You can roll it THIN with MORGOILS

Morgoils are being used to roll aluminum foil down to .00025" and are preferred for the temper passing of tin-plate stock, and the rolling of other light-gauge metal. This requires a bearing with the ability to carry sustained heavy loads and to maintain very close tolerances in the rolled product. That's why Morgoils are being installed in so many new and old stands.

Whether you roll it thin or thick, you'll roll it better on Morgoils.

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

English Representative
INTERNATIONAL CONSTRUCTION CO.
56 KINGSWAY, WC2, LONDON, ENGLAND

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MORGAN WORCESTER
Rolling Mills - Wire Mills - Gas Producer Machines - Regenerative Furnace Control

MORGOIL
ROLL NECK BEARINGS

Route this ad through your plant...

IT CAN SAVE YOU THOUSANDS OF MAINTENANCE DOLLARS

HOW YOU CAN HELP US TO HELP YOU

This message can help your company save money many ways. It can also be a source of information which will aid the work of every man and department in your company whose job is connected with preventing wire failures. After you've read it, please see that it reaches the right men. We'll appreciate it, and we think they will too.

You need no longer tolerate wire failures due to high ambient temperatures, overloads, deterioration caused by aging, oil, grease or corrosive fumes.

Because—a permanent insulation of heat and flame resistant impregnated asbestos gives Rockbestos A.V.C. wires and cables a long, trouble-free service life. This ageless insulation won't bake brittle, crack or flow under continuous 230°F. operating temperatures—and it has ample moisture resistance for conduit installations.

Rockbestos A.V.C. pays its way many times over by eliminating the need for frequent re-wiring caused by failure of ordinary insulation in hot spots.

Types AVA, AVB, AVL and AIA for control, lighting and power circuits in 600 to 5000 volt ratings. Write for recommendations and samples—or, if you prefer, the Rockbestos engineer nearest you will call.

ROCKBESTOS PRODUCTS CORP., 622 NICOLL ST., NEW HAVEN 4, CONN.

NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO
PITTSBURGH ST. LOUIS LOS ANGELES OAKLAND, CALIF.

A few of the 125 different permanently insulated Rockbestos wires and cables designed to protect operations and reduce maintenance in control, lighting and power circuits. From left to right:

Type AVA 600 Volt Rockbestos A.V.C. Power Cable*
Type AVA 600 Volt Rockbestos A.V.C. Boiler Room Wire
Type AVB 600 Volt Rockbestos A.V.C. Switchboard Wire

*Other single and multi-conductor cables up to 5000 volt rating—also with lead sheath, armor or lead sheath and armor coverings.

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

P-G *Steel Grid Resistors for* BETTER PERFORMANCE

...WITH *Low Cost Maintenance!*

Rugged

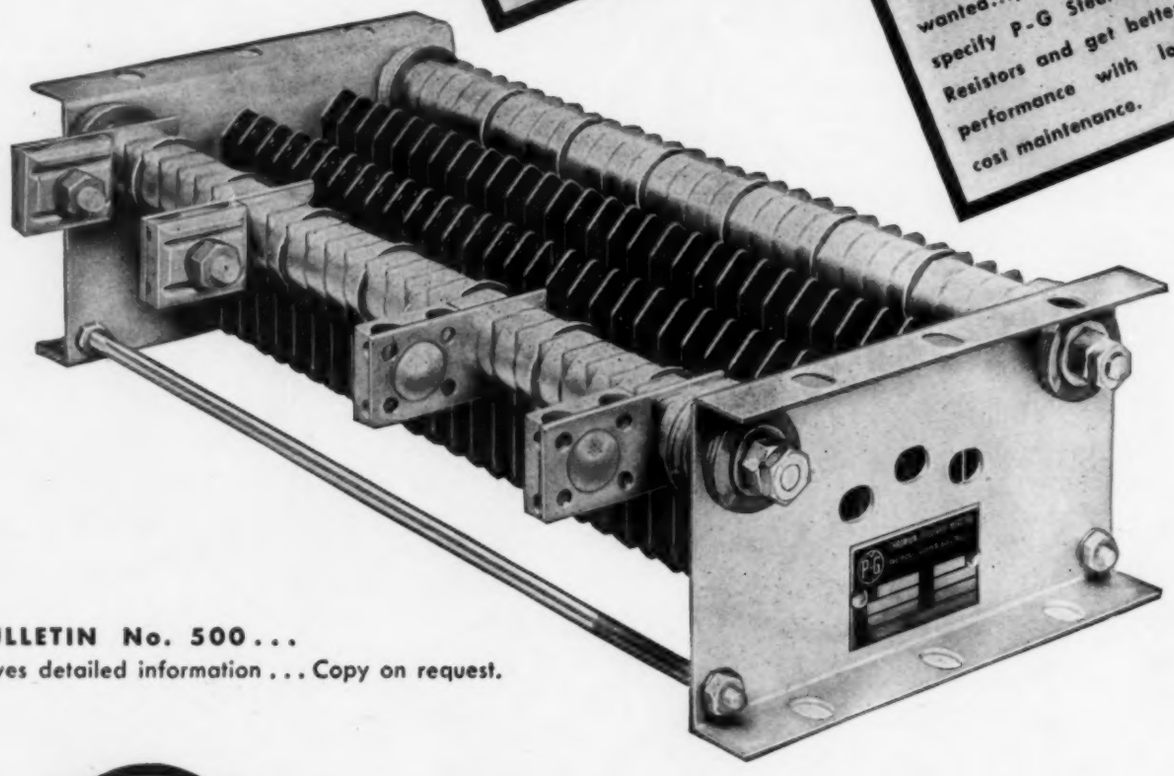
Built of Steel and Mica—nothing to break. Light in weight and dependable. Remarkably constant resistance values regardless of temperature or age.

Original Grid Design

Provides a shape assuring maximum ventilation. Heat is evenly distributed. With all parts of grid equally exposed, heat is rapidly dissipated.

For any job

Where constant "trouble free" resistor service is wanted...you can safely specify P-G Steel Grid Resistors and get better performance with low cost maintenance.



BULLETIN No. 500...
Gives detailed information . . . Copy on request.

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

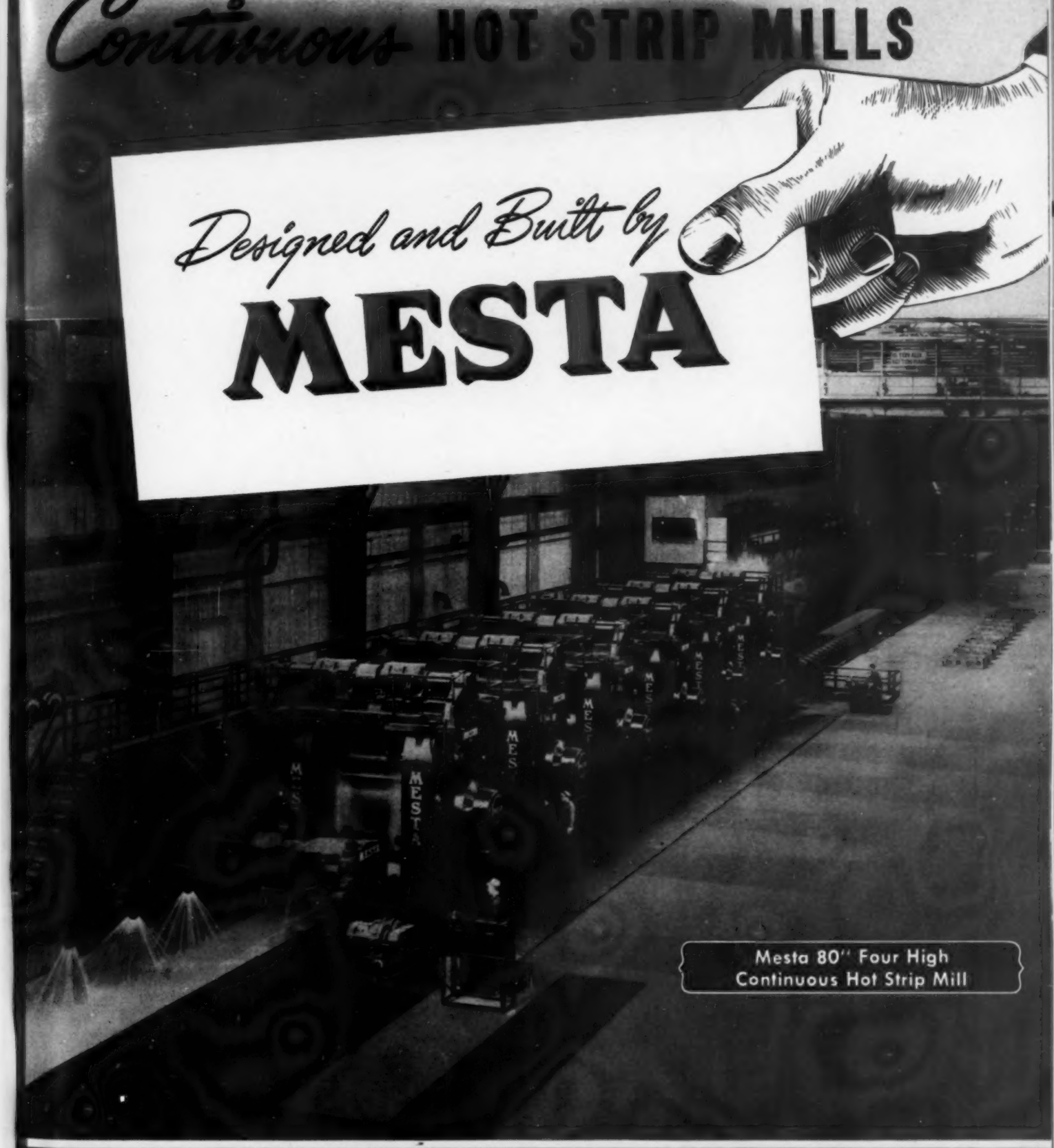
• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

Continuous HOT STRIP MILLS

Designed and Built by

MESTA

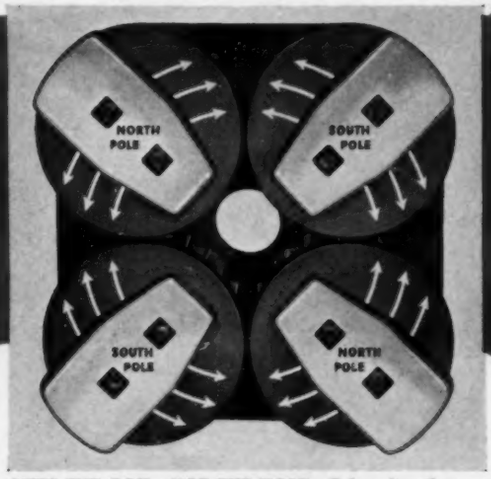


Mesta 80" Four High
Continuous Hot Strip Mill

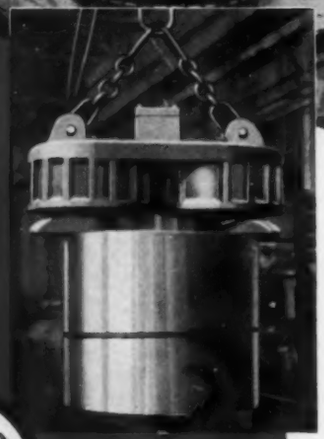
DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.

Protects the Surfaces--and Gives High Storage Capacity --remember the CSM Magnet for FINISHED COIL Handling.



LIFTS THE COIL—NOT THE HOLE. Poles directly over coil wall give high flux density at each pole shoe contact.



Exclusive Advantages of the CSM Design

1. Lifts coil without tilting—reduces chance of injury to bottom of coil when setting coil down.
2. Nothing adheres magnetically to bottom to injure coil when it is again set down. Does not disturb coil below when lifting top coil from the pile.
3. Operator can center magnet on coil easily—magnet does not hide his view of the load.
4. Magnet can deposit coil in or remove coil from confined passages without disturbing surrounding piles or objects—minimum overhang allows compact storing.
5. Permits high piles of coils—increases storage capacity over given floor area.

Type CSM Magnets are designed specifically to handle finished coils carefully and without delay. Coils are moved quickly and safely between roll stands and annealing furnaces—in and out of storage areas—and similar movements where protection of the finished product is paramount. Ask for Bulletin 902 which fully describes these magnets.

FOR A SPECIFIC PROBLEM PLEASE ADVISE

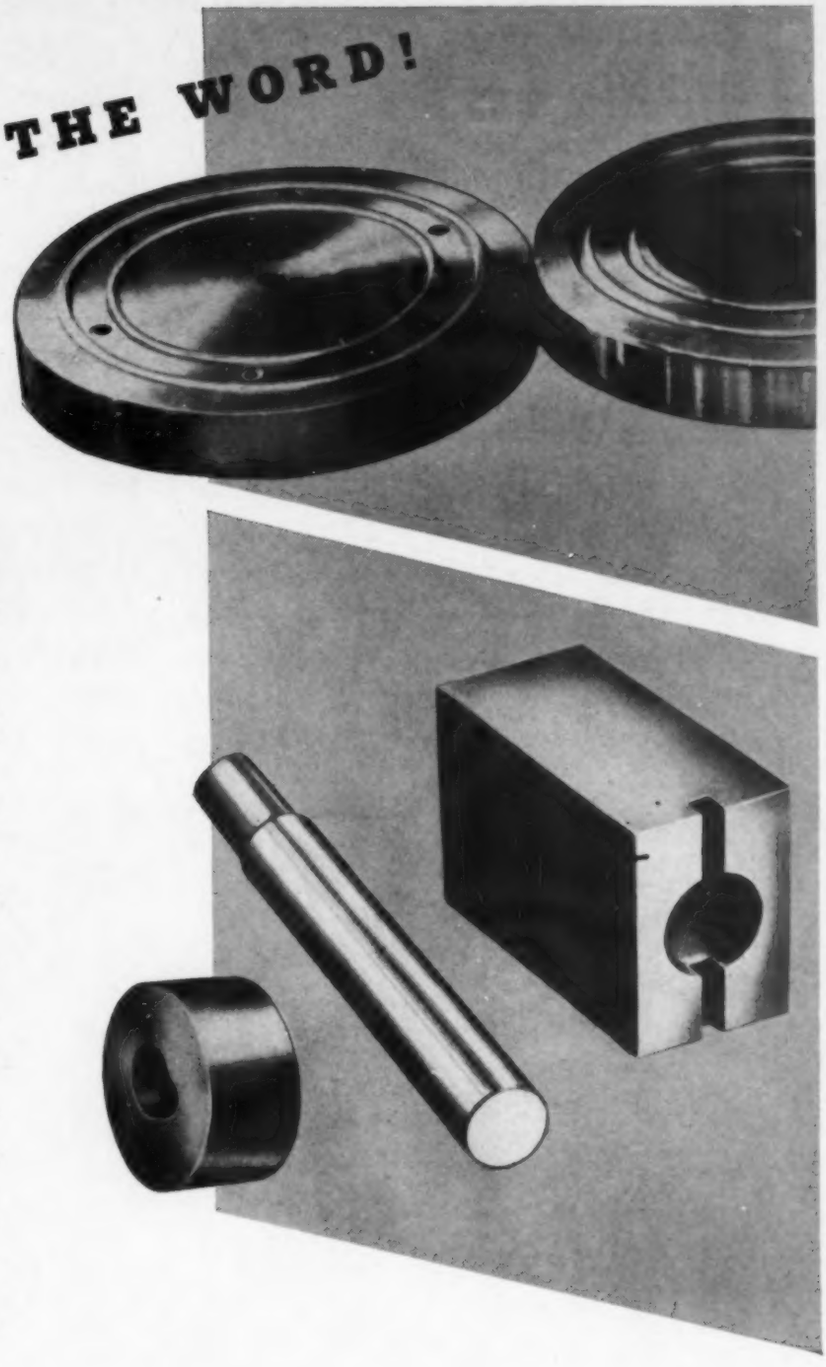
1. Inside and outside diameter of coil
2. Weight of coil
3. Gauge of strip
4. Type of coil (tightly or loosely wound)
5. How banded and how smooth on top (evenness of turns)

EC&M's Fiftieth Anniversary

THE ELECTRIC CONTROLLER & MANUFACTURING CO.

2698 E. 79th St. Cleveland 4, Ohio

CONSTANT IS THE WORD!



Midvale Constant tool steel is what its name implies . . . unchanging in form and dimension, invaluable where non-distortion in hardening is an important factor. Constant is an electrically melted alloy tool steel made of hand-picked raw materials. It has great depth of hardness—is exceptionally wear-resistant and free from cracking. It files, grinds, machines—has fine cutting qualities. This versatility makes Constant ideal for many types of cutters, hobs, reamers, dies, jigs, punches, gauges, press and forming tools and chasers.

THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA

OFFICES: NEW YORK • CHICAGO • PITTSBURGH
WASHINGTON • CLEVELAND • SAN FRANCISCO

MIDVALE
Custom Steel Makers to Industry

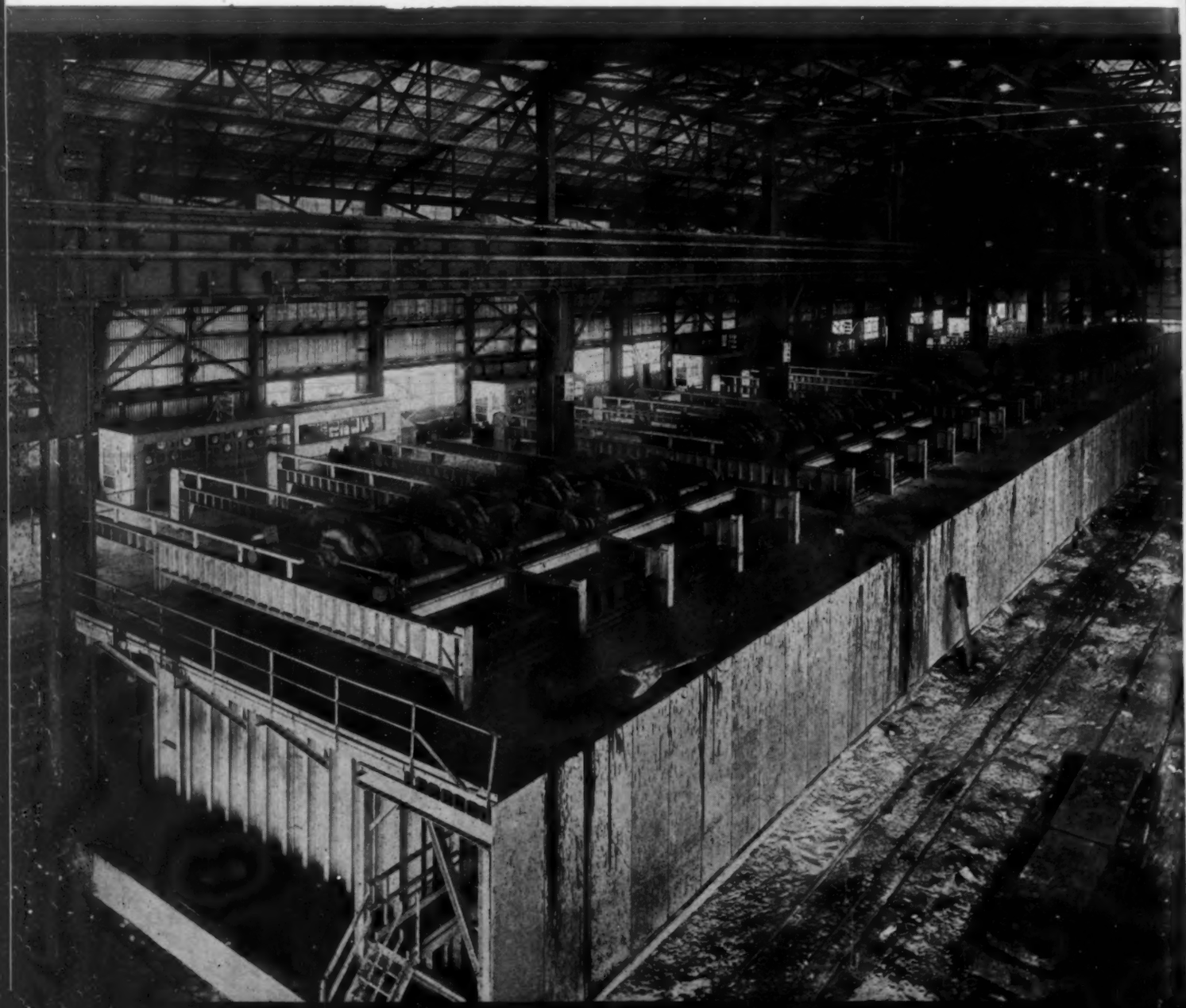
STAINLESS AND TOOL STEEL BARS
•
CORROSION AND HEAT RESISTING CASTINGS
•
FORGINGS AND RINGS

Ever since the first 'Surface' One-Way Fired Soaking Pit was installed in 1926, our engineers have been working with steel men in the continuous development of metal heating equipment to meet the prevailing production need.

Today, 'Surface' One-Way Fired Soaking Pits incorporate the most modern features in design and operation to make possible high quality as well as quantity tonnage.

Most significant is the fact that during the nineteen years of 'Surface' Pit engineering, the One-Way Firing principle has remained the most satisfactory method of ingot heating. It is convincing to see 'Surface' Pits in operation. Furthermore, 145 One-Way Fired Pit installations have been made since 1936...66 since 1942, which is most indicative of an industry trend to proved heating methods and equipment.

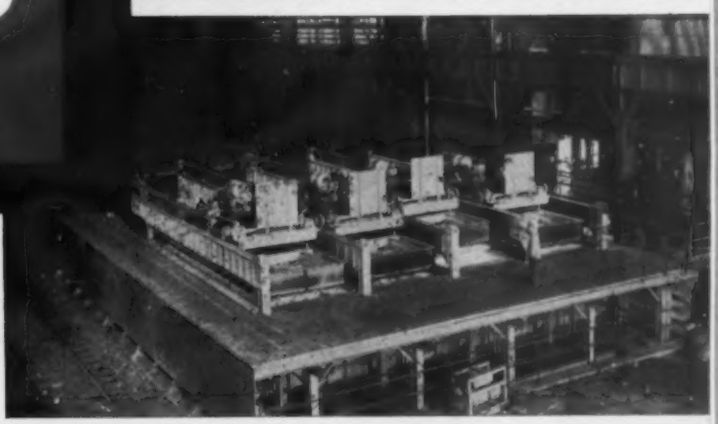
These outstanding advantages are offered in 'Surface' One-Way Fired Pits: Simplest Construction; Greater Capacity; Most Efficient Firing; Best Heat Distribution, and Lowest Maintenance. Ask a 'Surface' Engineer for details.



'SURFACE' ONE-WAY FIRED PITS

in the country's leading

STEEL MILLS

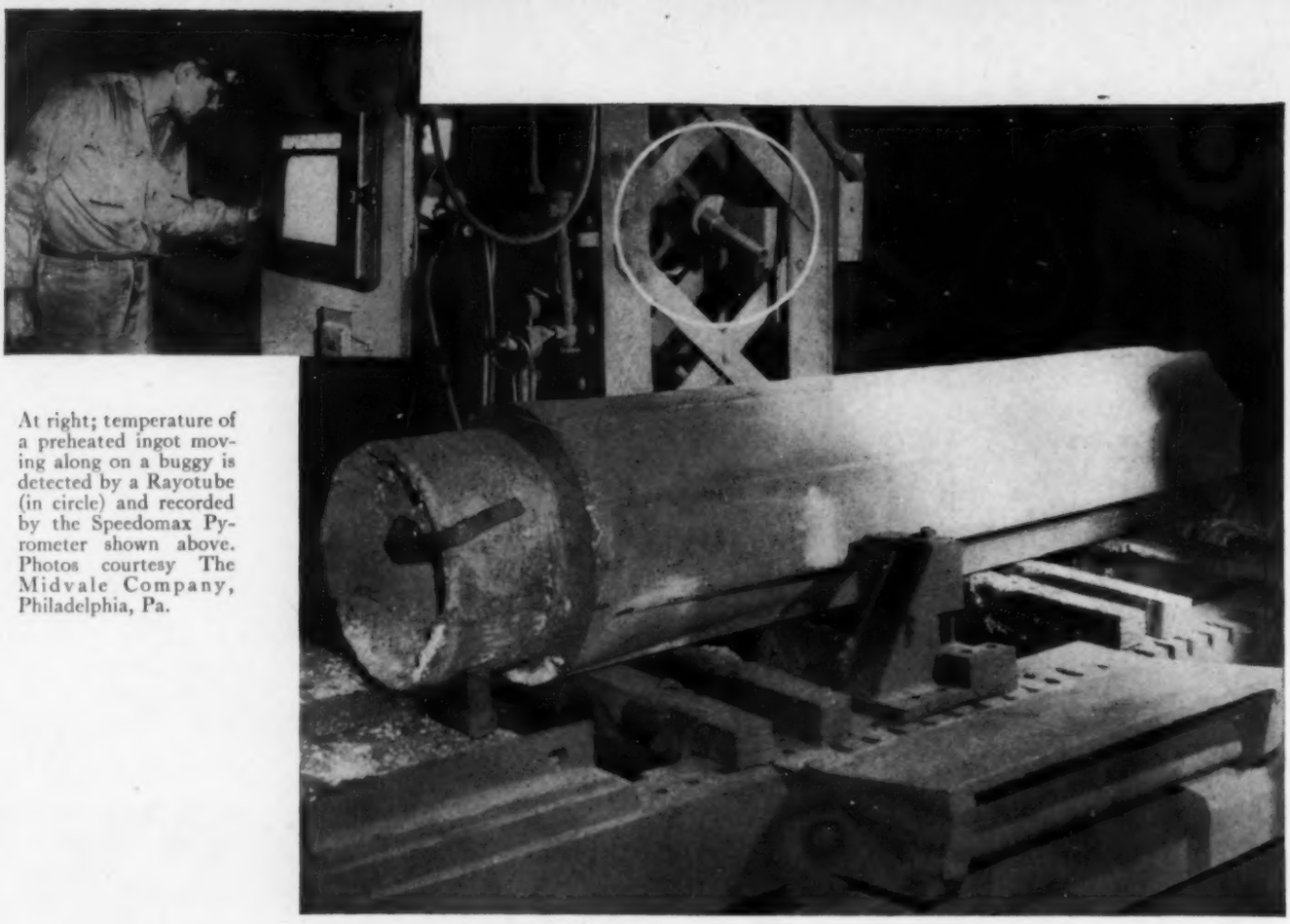


'Surface

SURFACE COMBUSTION CORPORATION

TOLEDO 1, OHIO

"WHEREVER HEAT IS USED IN INDUSTRY
...FROM INGOT TO FINISHED PRODUCT"



At right; temperature of a preheated ingot moving along on a buggy is detected by a Rayotube (in circle) and recorded by the Speedomax Pyrometer shown above. Photos courtesy The Midvale Company, Philadelphia, Pa.

Moving Ingots Report Temperature to SPEEDOMAX Pyrometer

In The Midvale Company's shop, a Speedomax Pyrometer with a Rayotube temperature detector measures the temperature of ingots as they start on their way to be made into locomotive tires. Straight from the preheating furnace, each ingot is loaded onto a buggy which takes it to the first step of fabrication. As the buggy moves along its tracks, the ingot passes in front of the Rayotube, which receives radiant heat from it and sends the Speedomax Recorder a report of temperature.

The Speedomax draws a detailed record of ingot temperature from top to bottom. As each ingot goes past, the operator can see by its record if it's too hot and should be held for cooling, or if it's too cold and should be sent back to the furnace.

The recording operation is entirely automatic. Each new ingot gets its temperature on record without any attention from the operators. There's no delay for manual measurements with a surface thermocouple or optical pyrometer — the latter couldn't be used anyway because the desired temperature is below its range.

Both Recorder and Rayotube are sturdily built for continuous operation under heavy industrial service. They're practically insensitive to vibration, yet highly sensitive to temperature. Both are stable in calibration, and are reliably accurate, in addition to being fast-responding to meet the needs of high-speed recording work.

If you have a moving-temperature application, an L&N engineer will be glad to call at your plant to discuss it with you. Or, if you prefer, we'll send Catalog N-33B. Write to Leeds & Northrup Company, 4942 Stenton Avenue, Philadelphia 44, Pa.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad N-33B-685(3)

...These teeth slashed $892,528 from billet-conditioning costs!

A Leading Mid-Western Steel Plant using Bonnot Billeteers recently set-up a cost study program to determine the economy of machine billet chipping as compared to other conditioning methods. The study covered 24,965 tons of billets ranging in size from 4" x 4" to 8" x 8". To eliminate all possible variables billets were conditioned by each method through a range of different heats.

Results of this study showed that Billeteer conditioning cost 56% less than hand chipping, 39% less than hand scarfing. These percentages were then used to determine the savings effected during the prior five year period. For purposes of comparison, Billeteer conditioning cost was set at $1.00 per ton with basic rates for other methods being adjusted to conform with actual differentials revealed by tests. Here are the figures:

BILLETEER	**714,022**	**$1.00**	**$ 714,022**	———
HAND SCARFING	**714,022**	**1.63**	**1,163,856**	**$449,834**
HAND CHIPPING	**714,022**	**2.25**	**1,606,550**	**892,528**

Billeteer savings over hand scarfing were almost half a million dollars.
Billeteer savings over hand chipping were not far from one million dollars.

Here's HOW The Billeteer Cuts Conditioning Costs

INCREASES MAN-HOUR PRODUCTION . . . a single Billeteer operator can do the work of 10 hand chippers . . . and do it better.

INCREASES SCRAP RECOVERY . . . every Billeteer chip "comes clean"—classified as to analysis—ready for the charging box.

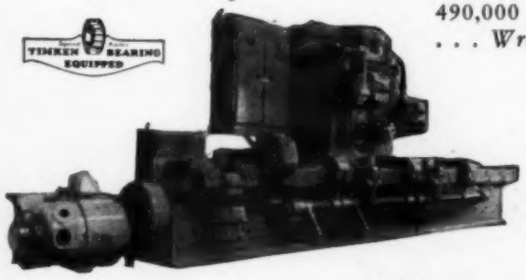
SPEEDS CRITICAL DELIVERIES . . . by permitting reclamation of bad billets and even bad heats, it facilitates maintnance of delivery schedules — reduces pick-up items at the melt shop.

INCREASES BILLET SALVAGE . . . Billeteer's low operating cost permits recovery of badly seamed billets unprofitable to salvage by other methods.

REDUCES BILLET INVENTORY . . . since otherwise "unsalvageable" billets can be saved, inventory of billets and ingots can be reduced to a minimum.

INCREASES WORKER EFFICIENCY . . . the Billeteer's 45 ton weight takes the punishment of chipping — saves workers from jitters, fatigue, and illness.

And . . . these savings were accomplished with only one disabling accident in 490,000 Billeteer man-hours. Learn how much the Billeteer can save YOU. . . . *Write for full information.*



Engineered
FOR LOWER OPERATING COSTS
BONNOT

builders of the BILLETEER • THE BONNOT COMPANY • CANTON 2,

FROM THIS MOUND

better MELTING!

better MOLDING!

In this form, it's petroleum coke... just a good fuel. But it is potential *graphite,* too! Properly processed, it will become graphite electrodes, molds, mold plugs, and the variety of specialized graphite products made by International that show the way to increased production and lower costs.

Graphite resists thermal shock—it will not crack, spall or chip. Its low thermal expansion insures castings true to specified dimensions. Molten metal does not "wet" graphite—no sticking in the mold. And graphite has virtually no melting point—ingots and castings are free of inclusions. In addition, it is light in weight, low in cost.

These properties of graphite may suggest new time and cost saving applications in your plant or help you to solve difficult melting. casting and molding problems. International supplies graphite in blocks, tubes, slabs, or machined to your specifications—and graphite electrodes for all types of electric furnaces.

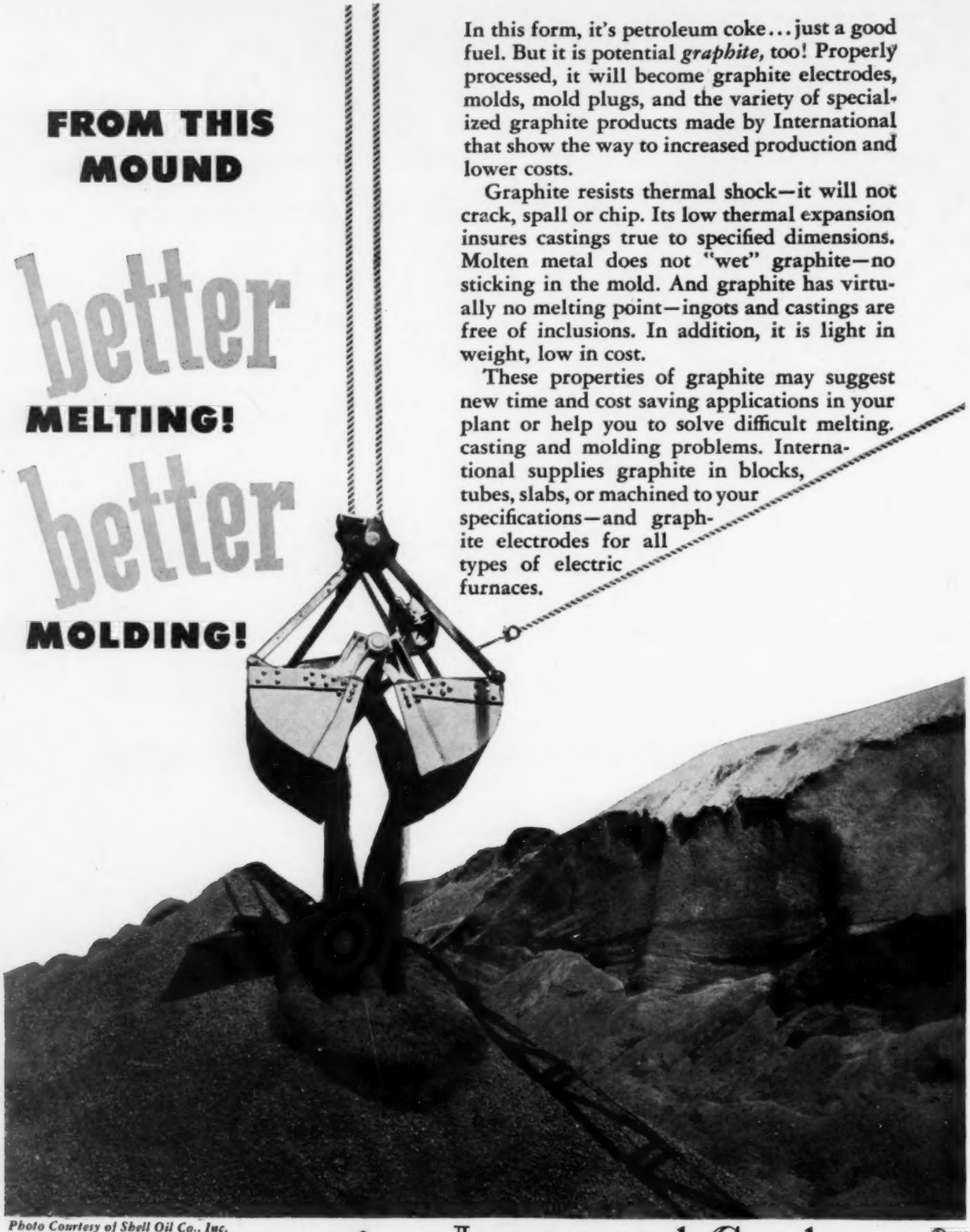


Photo Courtesy of Shell Oil Co., Inc.

3569

International Graphite & Electrode Corp.

SAINT MARYS, PA.

Designed and Built by

Merchant Mill,
Finishing End

UNITED ENGINEERING AND FOUNDRY CO.

PITTSBURGH, PENNSYLVANIA

Plants at **PITTSBURGH • VANDERGRIFT • NEW CASTLE • YOUNGSTOWN • CANTON**

Subsidiary: **Adamson United Company, Akron, Ohio**

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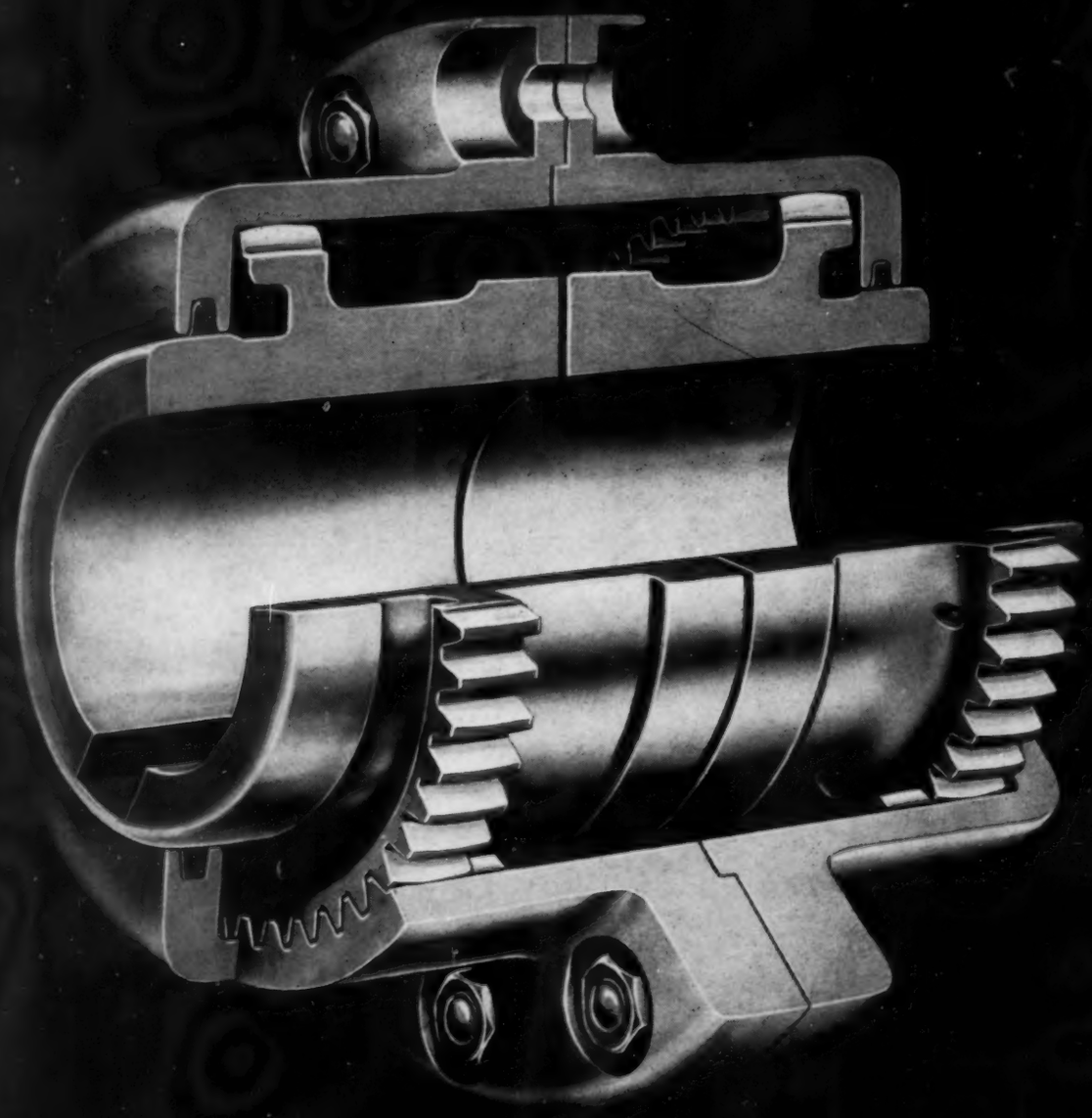
S. E. C. I. M., Paris, France

DESIGNERS AND MAKERS OF ROLLS AND ROLLING MILL EQUIPMENT

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

PRODUCT *Information*

ON ANY OF THE PRODUCTS MENTIONED IN THIS ISSUE

elow is an index of products referred to in editorial and advertising pages of this issue. If you desire additional information on any of em, use one of the accompanying postcards in requesting it. In each case give name of product and page number. The information ill come to you directly from the manufacturer involved.

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IRON AND STEEL ENGINEER March, 1948

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PITTSBURGH 22, PA.

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1010 EMPIRE BUILDING

PITTSBURGH 22, PA.

Large Jobs or Small

F. E. I.

PATENTED COMBUSTION SYSTEM

Does Your Heat Treating **RIGHT**

You'll get perfect heat treating at low cost when your equipment is designed by Furnace Engineers. F. E. I. will do the complete job for you, from original analysis and design through final installation and check runs—giving you the benefit of experienced specialists in every phase.

If your heat treating process is not completely satisfying you are cordially invited to discuss your problem in detail with us under no obligation. Write today.

F. E. I. EQUIPMENT

- Direct-Fired Cover Furnaces for annealing, spheroidizing, Normalizing and Bright annealing of wire, rods, coiled strip, flat sheets and tin plate.
- For Heavy Coil Loads: Patented Convection Base, gives 2 to 4 times longer service.
- For Wire, Bar and Tube Mills: Galvanizing, Patenting and Normalizing Furnaces.
- For Pipe, Sheet and Job Plants: Hot Dip Galvanizing Furnaces.
- Car Type Furnaces, Rod Heating, Lead Quenching, Ladle Heating and Salt Bath Descaling Furnaces.
- Continuous Slab and Billet Heating Furnaces.
- Continuous Quenching and Tempering Furnaces — Quench Tanks, Water or Oil.
- Soaking Pits.

FURNACE ENGINEERS, *Inc.*

FOREIGN REPRESENTATIVES: For Canada: Salem Engineering (Canada) Ltd., Toronto, Ont. For Europe, Asia: Salem Engineering Co., Ltd., 124 Devonshire Street, Sheffield 1, England.

1551 WEST LIBERTY AVENUE ★ PITTSBURGH, PA.

Airco helps write new history for steel production

Early in 1946 Airco introduced in the United States a new combustion method that is pointing the way to future open hearth economies. This new technique, employing the oxygenated fuel flame, helps reduce meltdown time by accelerating the heat input rate.

Another forward step was taken in the summer of 1946. At that time, decarburization of steel by gaseous oxygen in open hearth furnaces was introduced. This promising technique, which is exciting the imagination of steel makers, involves a practical method of injecting oxygen directly into the molten steel bath through the slag cover.

Air Reduction, recognizing the importance of these developments, made the facts concerning them immediately available to the entire industry.

Now, this same forward thinking is at work in the perfection of other metallurgical uses of industrial gases for flushing, desiliconization, desulphurization, and similar related processes.

• • • •

For more data on oxygen as an aid to combustion and decarburization in the open hearth, as well as data on other new processes as they are developed, write us immediately. We will place your name on a list to receive all releases as they come out. Address: Dept. IS 8119, Air Reduction, New York 17, N. Y. In Texas: Magnolia Airco Gas Products Company, Houston 1, Texas. On West Coast: Air Reduction Pacific Co., San Francisco 4, Calif.

AIRCO **AIR REDUCTION**

Offices in All Principal Cities

Headquarters for Oxygen, Acetylene and other gases . . . Carbide . . . Gas Welding and Cutting Machines, Apparatus and Supplies . . . Arc Welders, Electrodes and Supplies

LONGER TIME BETWEEN GRINDS

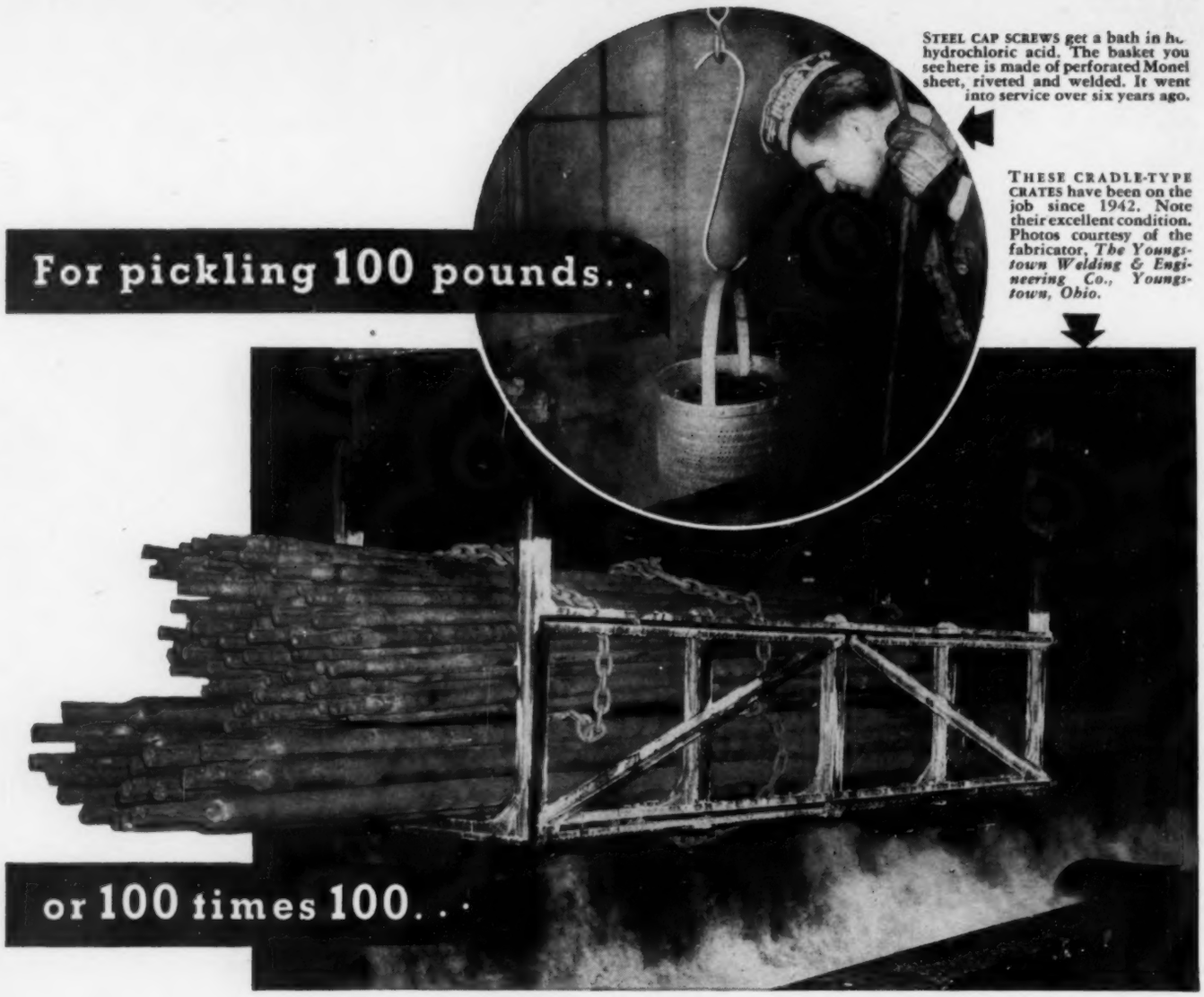
Roll value and rolling profits are determined by the number of hours your rolls can hold their size and shape in the mill—enabling you to turn out higher tonnage between dressings.

Lewis roll designers and metallurgists "work overtime" to make sure you get the rolls you need to make top production records.

LEWIS FOUNDRY & MACHINE
Division of Blaw-Knox Co.
Pittsburgh, Pa.

ALSO MANUFACTURERS OF
ROLLING MILL MACHINERY
FOR THE IRON, STEEL AND
NON-FERROUS
INDUSTRIES

LEWIS ROLLS



STEEL CAP SCREWS get a bath in hot hydrochloric acid. The basket you see here is made of perforated Monel sheet, riveted and welded. It went into service over six years ago.

THESE CRADLE-TYPE CRATES have been on the job since 1942. Note their excellent condition. Photos courtesy of the fabricator, *The Youngstown Welding & Engineering Co., Youngstown, Ohio.*

GET THE EXTRA FEATURES OF MONEL

There's no need to pile on ***dead*** weight when you want stronger, longer-lasting baskets or crates.

*Just use Monel**. It has plenty of *extra* strength and toughness. It resists corrosion by sulfuric acid and dilute hydrochloric acid pickling solutions.

With Monel, your equipment doesn't have to be made extra heavy to allow for rapid corrosion. You handle bigger pay loads faster . . . and with *safety*. You save time . . . labor . . . power . . . acid.

You save another way, too. *Even equipment that must be designed for a special job* can be readily fabricated from regular Monel mill forms (rods, bars, angles, etc.) Whatever its form, Monel is readily cut, bent, machined, forged and welded by ordinary methods. Welding doesn't reduce strength, toughness or corrosion resistance.

Remember all these advantages of Monel when a pickling problem has you stumped. Remember also, that experienced fabricators like THE YOUNGSTOWN WELDING & ENGINEERING COMPANY (who made the basket and rack shown above) can offer practical help in design and fabrication.

THE INTERNATIONAL NICKEL COMPANY, INC. *67 Wall Street, New York 5, N. Y.*

EMBLEM OF SERVICE

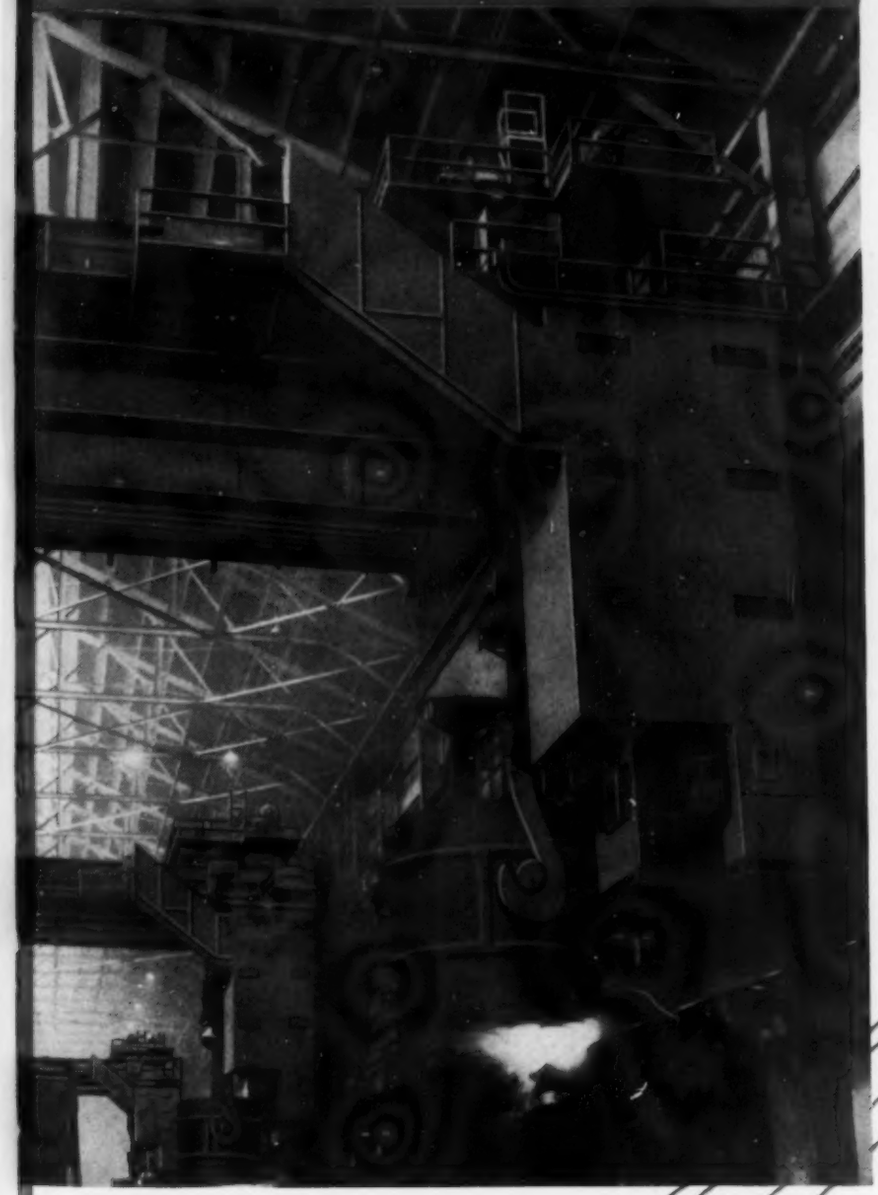
NICKEL INCO TRADE MARK ALLOYS

MONEL*

MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL • INCONEL* • NICKEL • "L"* NICKEL • "Z"* NICKEL

*Reg. U. S. Pat. Of

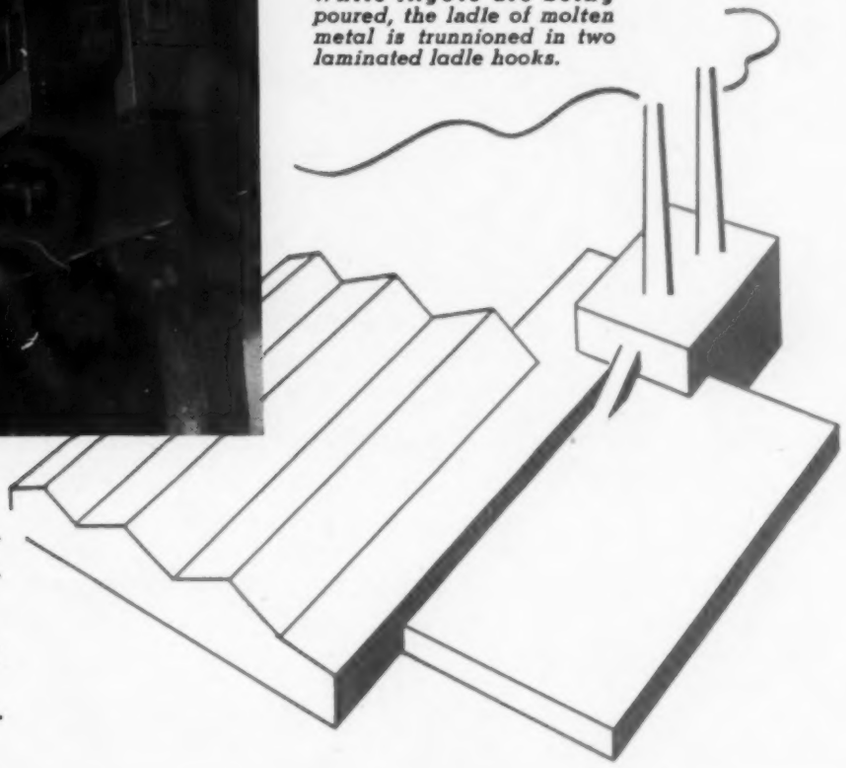
Alliance GIVES YOUR PLANT MORE LIFTING POWER



Alliance builds all types of cranes to convey slabs, ingots, hot metal, raw materials, and finished products safely, quickly, and easily. Shown here is a 275-ton, 4-girder Ladle Crane, equipped with an auxiliary trolley having a 60-ton and a 20-ton hoist. This crane has a safety compartment back of the enclosed operator's cab. The compartment contains a duplicate bridge master control, enabling the operator to move the crane in safety in case hot metal is accidentally spilled. Another safety feature is the enclosed stairway leading from the cab to the footwalk on the crane girder.

For fifty-odd years, Alliance has been known as the World's Largest Builder of the World's Largest Cranes. It always pays to check with Alliance . . . for the development of new cranes or reconversion of old cranes to give your plant more lifting power.

While ingots are being poured, the ladle of molten metal is trunnioned in two laminated ladle hooks.



LADLE CRANES—GANTRY CRANES—FORGING MANIPULATORS—
SOAKING PIT CRANES—OPEN HEARTH CHARGING MACHINES—

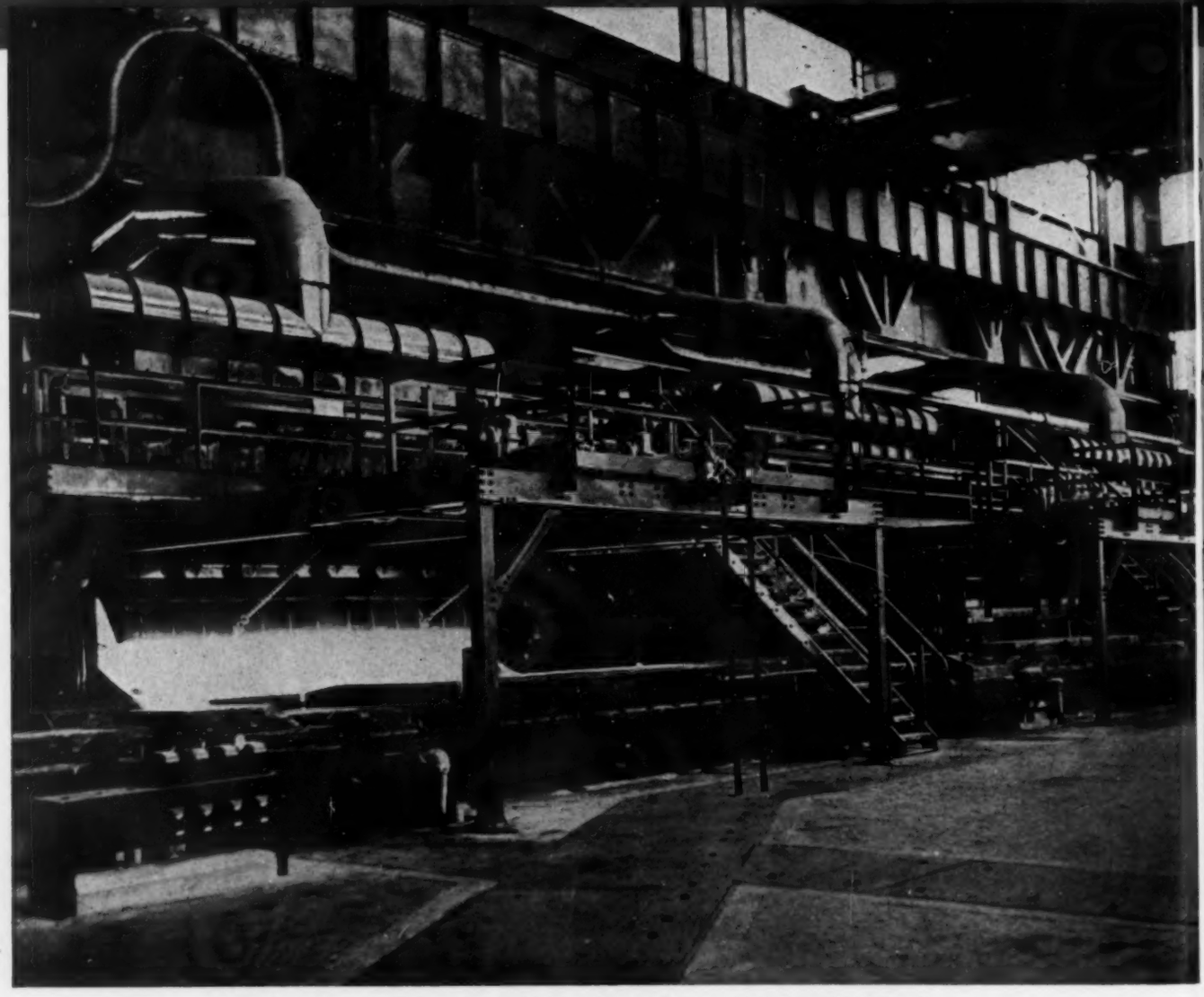
★ *Rely on* **ALLIANCE** *for:*

STRIPPER CRANES—SLAB AND BILLET CHARGING MACHINES—
SPECIAL MILL MACHINERY—STRUCTURAL FABRICATION

THE ALLIANCE MACHINE COMPANY

MAIN OFFICE: ALLIANCE, OHIO • PITTSBURGH OFFICE: 1622 OLIVER BUILDING, PITTSBURGH, PA.

Pioneered by *TWENTY-SIX*



Typical American Arch installation in the Pittsburgh district

AMERICAN ARCH

1430 Park Building, Pittsburgh, Pa.

REPRESENTATIVES: BIRMINGHAM • CHICAGO • CINCINNATI

American Arch
YEARS AGO

Since the American Arch Company entered the industrial field in 1922, the suspended arch with all metal supports outside and above the tile has been characteristic of American Arch design.

First to apply the metal supports *outside the insulating material,* American Suspended Arches offer outstanding advantages for all types of steel mill furnaces . . . heating furnaces . . . soaking pit covers . . . open hearth roofs (silica and basic materials), checker chambers and fantails . . . boiler furnaces.

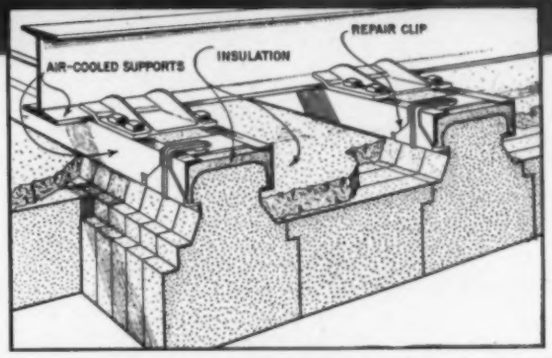
Full burning depth of tile is utilized because support is entirely external.

100% insulation, not broken at any point by metal supports, assures maximum fuel economy.

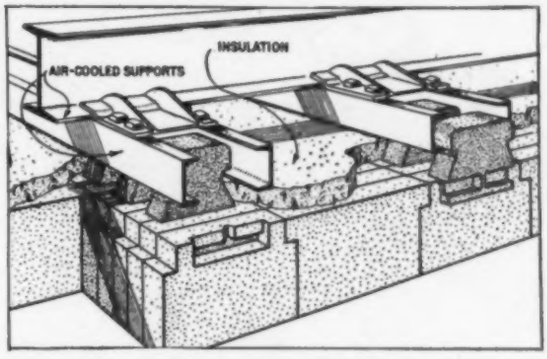
With supports outside insulation, it is unnecessary to use heat-resisting castings to avoid premature destruction of arch.

The metal supports get all benefits of air-cooling.

For any of your refractory problems you are invited to avail yourself of the recommendations of American Arch engineers.



A refractory hanger, which is part of the tile, has always been used by American Arch. This provides maximum burning depth of the refractory and keeps the metal supports outside the insulating material. It is conceded to be the only correct method of suspension to minimize heat losses and to assure long service life both of the tile and its metal supports.



Following the same principle of design, American Arch now separates the refractory hanger from the main body of tile. The hanger is made of harder material for greater supporting strength, and the arch tile more refractory to withstand high temperatures. No repair clips are necessary.

This new construction can be applied to existing installations without any change of main steelwork or the immediate supporting members.

COMPANY, Inc. INDUSTRIAL DEPARTMENT

60 East 42nd Street, New York, N. Y.

CLEVELAND • DENVER • DETROIT • LOS ANGELES • PHILADELPHIA

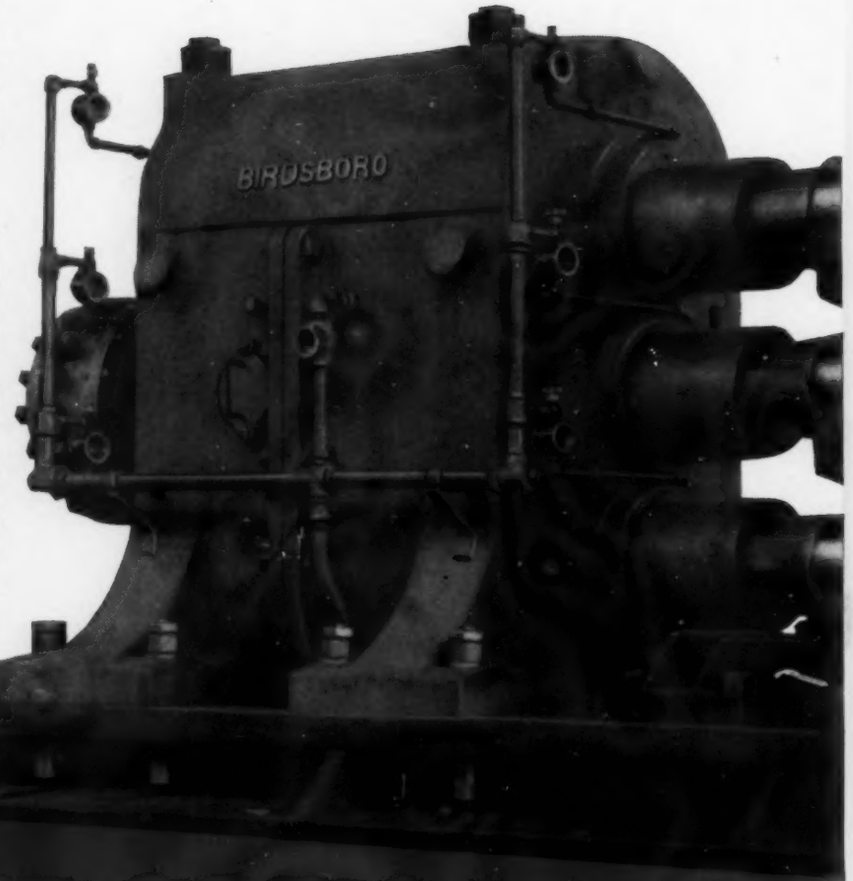
Reduce

STOP and GO ROLLING

Keep

If you are looking for long, uninterrupted service in steel mill equipment, put the job up to a Birdsboro Rolling Mill like the one shown here. This is a 20" 3-high bar mill that has been soundly designed and engineered to produce greater tonnages of accurately rolled shapes at minimum operating and maintenance costs.

This mill is of rugged, all-steel construction and its up-to-date design incorporates many features that speed production and simplify its operation. The open top roll housings have housing caps designed for quick roll changes. The top and bottom rolls are easily adjustable. The feed roll is chain driven on the entering side. And the totally enclosed pinion housing has forced feed lubrication of pinion teeth and bearings. Consult Birdsboro when you have any mill equipment or special machinery problem.

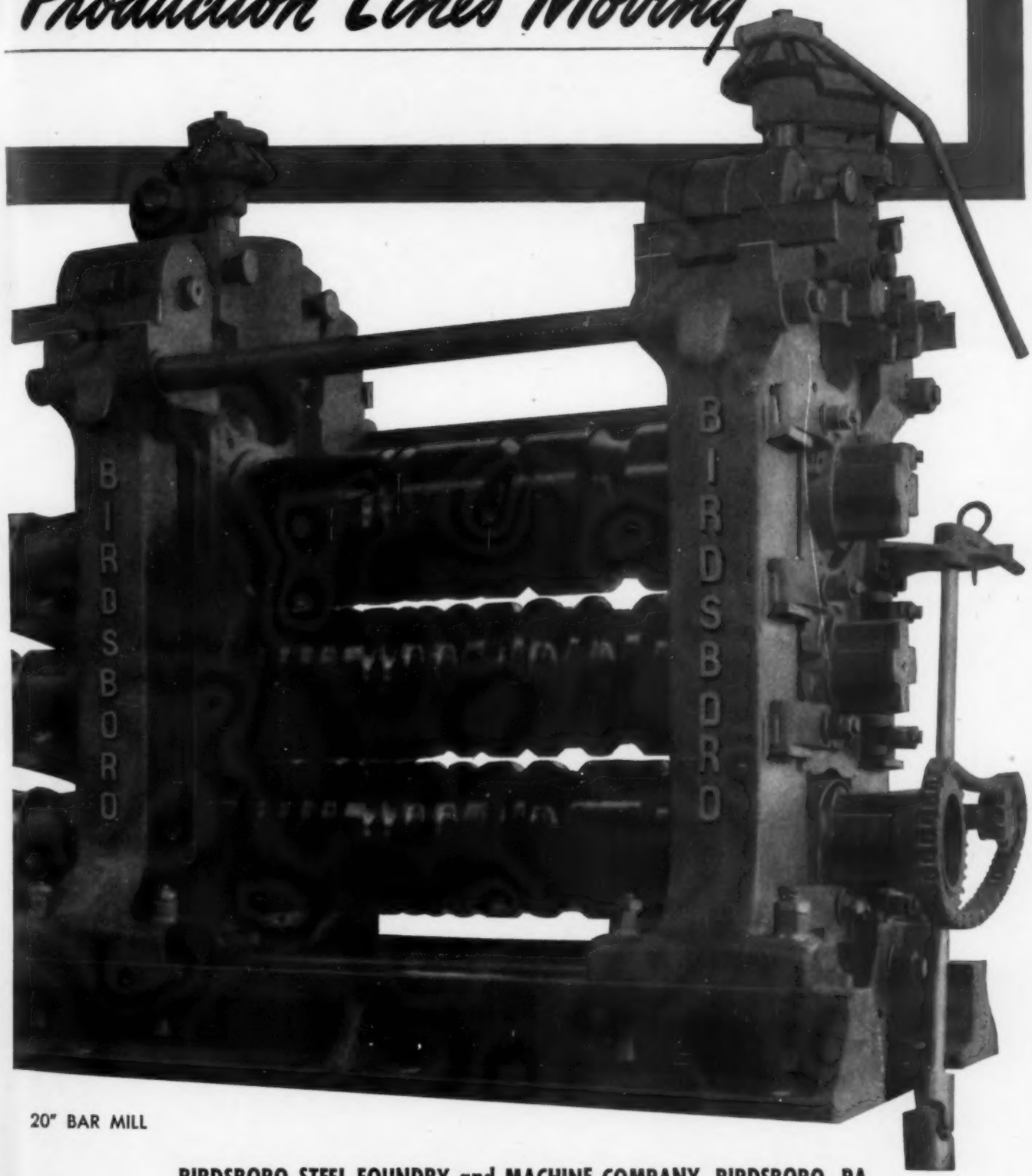


BIRDSBORO

STEEL MILL EQUIPMENT

DESIGNERS and BUILDERS of: Steel Mill Equipment • Hydraulic Presses • Rolls
Special Machinery • Steel Castings

Production Lines Moving



20" BAR MILL

BIRDSBORO STEEL FOUNDRY and MACHINE COMPANY, BIRDSBORO, PA.

OFFICES IN: Birdsboro, Pa. and Pittsburgh, Pa.

REPRESENTATIVES AT: 332 South Michigan Ave. Chicago 4, Illinois — 507 Terminal Tower Bldg. Cleveland 13, Ohio

In every detail, Cleveland Steel Mill Cranes are especially designed for steel mill service. There is no adaptation of parts intended for general purpose cranes. There is no compromise in construction. Mechanically and electrically, Cleveland Steel Mill Cranes are built to meet hard mill service conditions and perform faithfully year in and year out.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops *and* Shorts

DURING 1947, expenditures by the iron and steel industry for new equipment and expansion totaled $496,000,000. This does not include expenditures for maintenance. Amounts set up for the same purposes in 1948 total $565,000,000. Another $265,000,000 is already allocated to be spent beyond 1948, although 1949 plans are not yet complete and additional expenditures will be forthcoming.

The 1948 figure brings the total amount spent by the industry since VJ-day for new equipment and expansion to $1,400,000,000 — not bad for an industry reputed to be against expansion. In fact, this amount is about twenty-five per cent of the actual prewar incorporated worth of the industry. Sad to relate, however, the gain in capacity is not in proportion to monetary figures, but only amounts to about 4 per cent — just another effect of the inflation which some sources have blamed the steel industry for starting.

▲

A MEMBER of the British Parliament observed: "The dollar shortage is no more than a symptom of the fact that America is producing plenty of goods while we are merely producing plans."

▲

DURING the twelve years 1935-1946, tax collectors received more money from the steel industry than the industry earned as its net profits, according to the American Iron and Steel Institute. Tax payments by the industry totaled over $3,737,000,000, while profits totaled about $2,243,000,000.

▲

THE Census Bureau has it figured that if every man had his right woman, there would be 1/30th of a woman left over for a stock dividend.

▲

BY this time, every one probably agrees that the latest steel price increase announcement, affecting semi-finished steel, was poorly timed. The actual increase is not particularly important, as it affects only 4 per cent of the total tonnage of the industry, and in the case of some companies, only one per cent of their production. Also, the increase is not exactly unwarranted, as the price of semi-finished steel was only about $5 above the price of scrap. It is principally a question of timing.

There may be some reasoning too deep for us to grasp in making this announcement immediately following publication of alleged record profits, and in the face of wage discussions and governmental investigation, but it certainly was not done with an eye to public opinion.

Big industry has often shown a certain ineptness in its public relations that is usually blamed on its conservative viewpoint and its unwillingness to "stick its neck out." In case after case, industry's side of disputes does not receive the public favor it deserves. True, industry must be more exact, more accurate in its public statements than unions need be. It would seem, however, that corporations might well put a little more appeal in their public relations without loss of dignity — after all, we sugar-coat pills and package them nicely to add public appeal without harming their medicinal value.

▲

IN case you're interested, University of Maryland scientists have calculated the well-known snail's pace at 0.000363005 miles per hour.

▲

THEY say that everyone has some useful purpose in life — like serving as a horrible example, huh?

▲

SOME of our left-ish citizens who go into dithers over the lot of the poor working man in the United States might well look over the following statistics, taken from figures assembled by the New York Times:

	Average cost in work, hr-min.	
	Russia	U.S.A.
Veal, lb	5-15	0-34½
Sugar, lb	2-34	0- 5½
Butter, lb	10-42	0-48½
Tea, lb	11-0	0-39½
Coffee, lb	14-6	0-22½
Eggs, doz	4-57	0-38½
Milk, qt	1-18	0-10
Vodka (whiskey), pt	23-50	1-35
Cigarettes (20)	2-4	0-9
Men's shoes, pair	104-30	7-15
Men's wool suit	580-15	28-4

▲

GRANDMA really didn't have more clothes than the modern girl. She just put them all on.

▲

IN 1947 the steel industry of the United States used 23,000,000,000 kwhr of electricity — approximately 275 kwhr per ton of ingots produced.

▲

BETWEEN 5,000,000 and 10,000,000 tons of high grade steel scrap are said to be lying idle at industrial centers in western Germany because the owners are reluctant to sell it to British and American purchasers. What would be wrong about insisting that it be given to us in part payment for the food and other aid we are supplying? It's about time we stop giving everyone everything they want and then paying them for what we need. And that goes for the stockpiles of strategic materials that we should be accumulating, as well.

Install *AIR BLAST* Metal-Clad S

PLAY IT SAFE!

Guard Against Damage to Valuable Mill Equipment • Protect Rolling Mill Motors by Rapid Clearing of Faults • Provide Complete Safety for Your Men • Install Factory-Built, Factory-Wired Allis-Chalmers Metal-Clad Switchgear with *Air Blast* Circuit Breakers

THIS IS THE *ONLY* DRAWOUT VERTICAL LIFT METAL-CLAD SWITCHGEAR equipped with *Air Blast* circuit breakers! That means a space-saving lineup of switchgear that is easily inspected and maintained . . . centralizes power control . . . protects personnel . . . and reduces potential fire hazards.

Drawout construction permits ready access to circuit breakers during inspection and maintenance—and interrupting with air blast reduces arcing time to less than a cycle insuring long contact life. *Air Blast* breakers are mechanically strong to withstand repeated "closing-opening" operations. *They consistently complete interruption within four to five cycles.* These 7.5 and 15 kv units have interrupting capacities of 250,000 and 500,000 kva.

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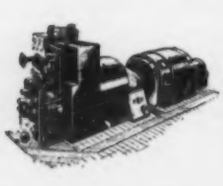

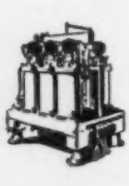

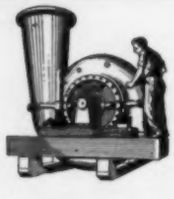

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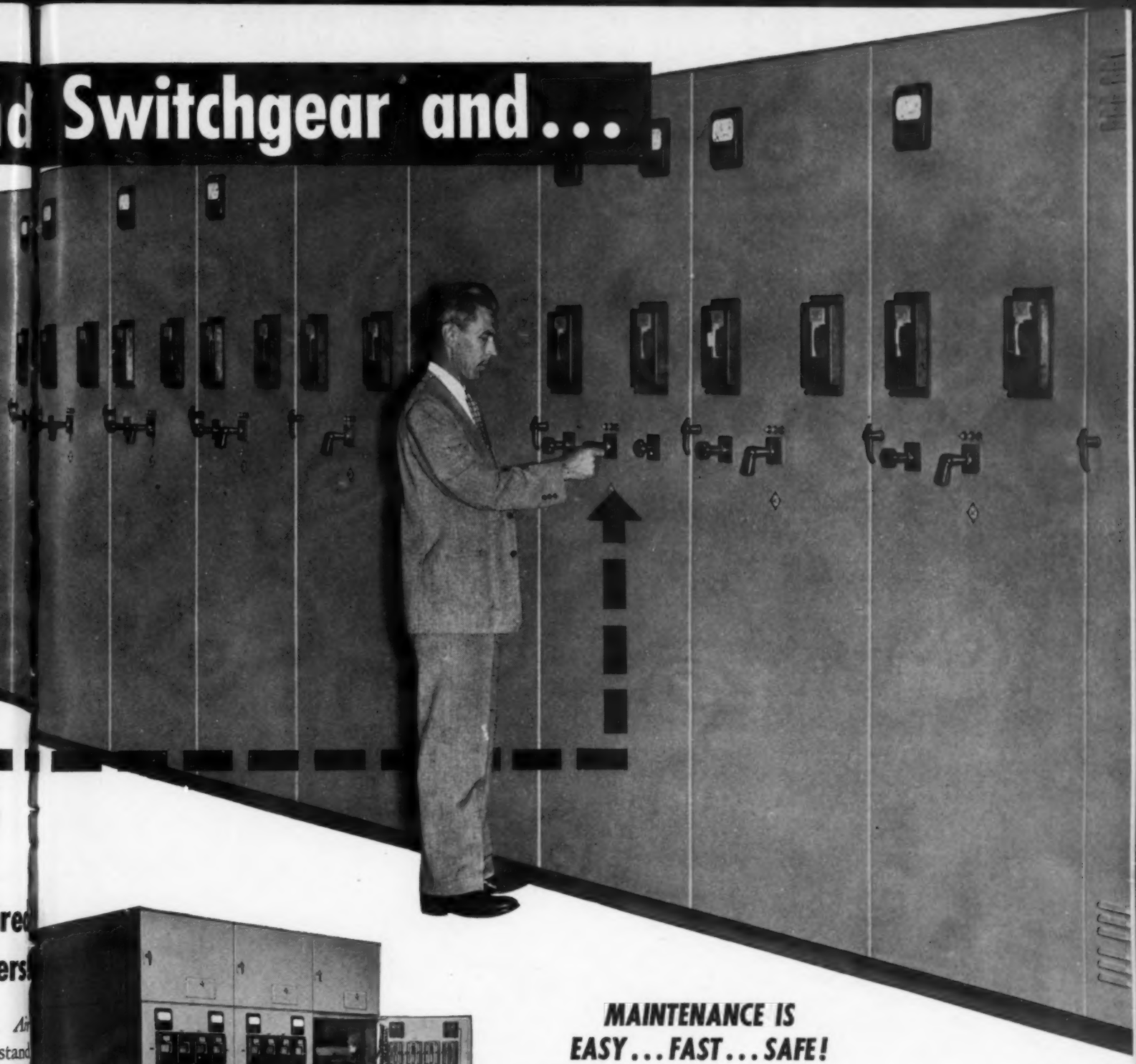

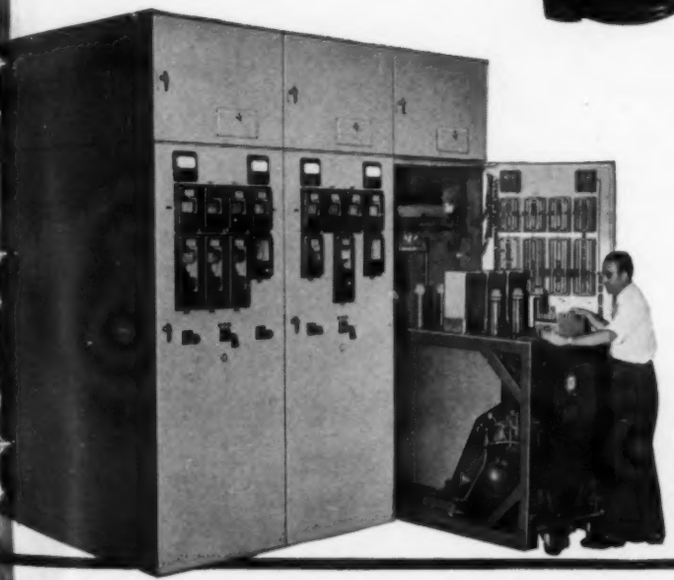

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Iron and Steel ENGINEER

MARCH, 1948 VOLUME XXV NUMBER III

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Published Monthly by
ASSOCIATION OF IRON AND STEEL ENGINEERS
1010 EMPIRE BUILDING
PITTSBURGH 22, PENNSYLVANIA

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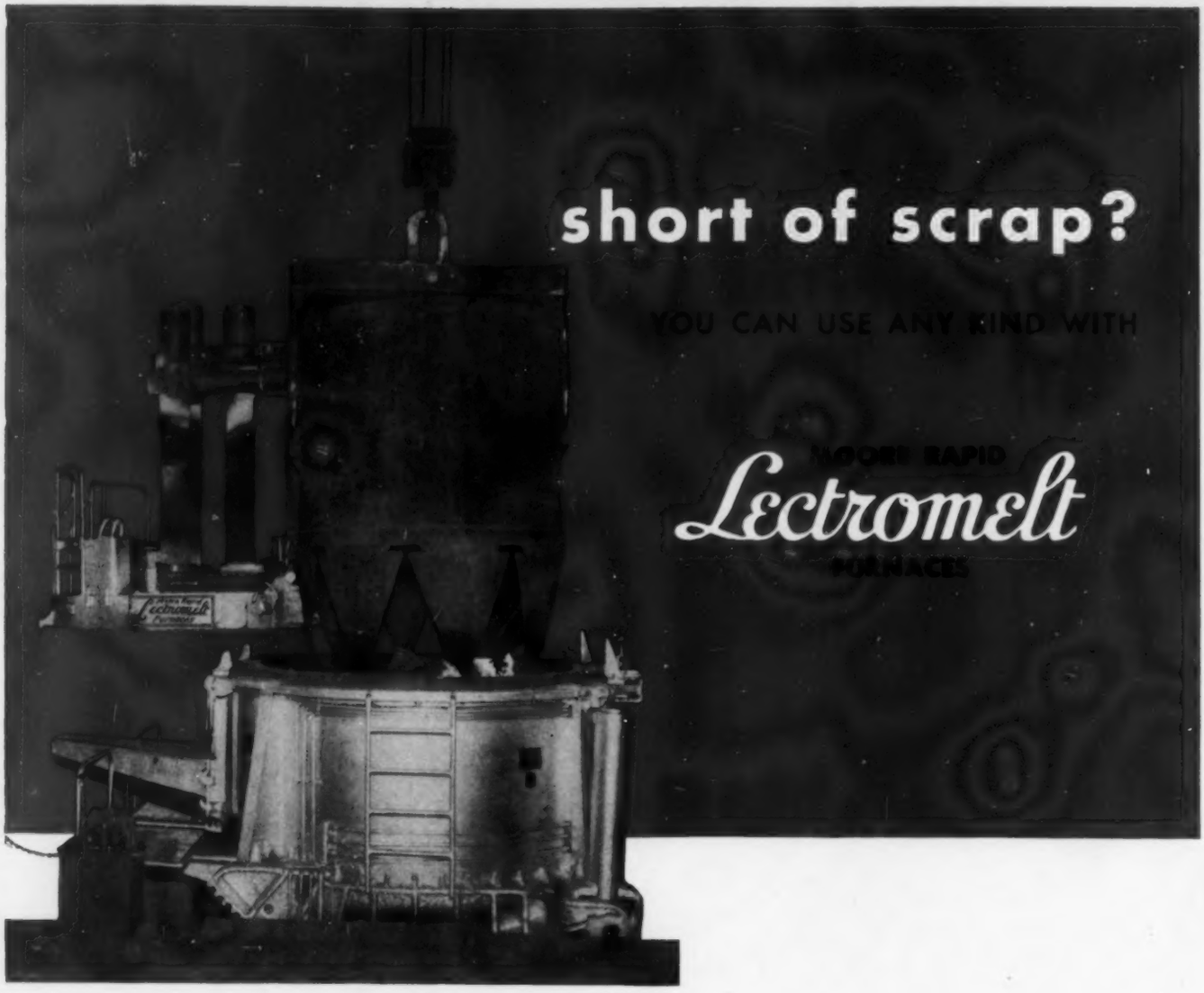

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The Use of Oxygen in OPEN HEARTH FURNACES

. . . . two of the problems yet to be solved before oxygen can be most economically used in the open hearth, fumes and roof life, are discussed in this paper . . . .

By E. C. McDONALD, Combustion Engineer, Republic Steel Corporation, Cleveland, Ohio

▲ AFTER conducting some preliminary experimental work on one 200-ton furnace in the Cleveland district for a period of two and one half months, Republic Steel Corporation management decided there was sufficient promise in the use of oxygen to justify the continuation of the experiment on a more permanent and extensive basis. The intensity and high luminosity produced from using burner injected oxygen to supplement the combustion air was so marked, it was decided to proceed even with present high oxygen cost. In addition, the use of oxygen enabled more fuel to be burned efficiently in an existing furnace. On account of the large hot metal charges used in this plant, it was recognized that in addition to melting down the scrap, large benefits could be derived by using oxygen instead of feed ore as a means of reducing carbon. This application had the advantage of the speed of oxidation of the bessemer process without the inherent metallurgical disadvantages of that method of steel production.

With these objectives in view a permanent 8 inch line 1000 feet long was installed between the oxygen plant and two open hearth furnaces with provision for extension to more as required. The piping facilities on the two furnaces provided for the use of oxygen in three ways: directly in the burners; through the checkers by being introduced into the air fan discharge; and for carbon reduction with a lance. This system was put in service December 9, 1946.

Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 23, 1947

The data for this paper were obtained from the experience in making 770 heats in the subsequent period up to September 1, 1947, using a combination of oxygen through the burners, and direct injection into the bath by means of a submerged pipe or lance. Total oxygen consumption for this period amounted to 7350 tons, or 176.3 million cubic feet. The use of oxygen enriched air through the checkers was abandoned early in the experiment because the benefits were not clearly perceptible. Oxygen consumption has ranged between 850 and 1300 cubic feet per ton, and over the series of heats averaged about equally between burner use and lances.

Other plants of Republic Steel Corporation are using oxygen with some success in open hearth and electric furnaces in lesser amounts, but the results are not covered in this report.

Before discussing the operational procedure, a brief description will be included of the piping layout, burner design, lancing arrangement and furnace design changes.

Piping arrangement — Figure 1 shows the general arrangement of piping, regulators, meters, solenoid operated reversing valves, valve box and lancing carriage on one furnace. Ninety-nine and one half per cent purity oxygen was supplied from liquid storage and regulated at the furnace manifolds to one hundred and thirty pounds. Each furnace was equipped with two regulators in case of failure of one, and in addition, to provide more capacity. Provision was made on each furnace to meter 88,000 cubic feet per hour, but piping facilities allowed a flow of 100,000 cubic feet. The total oxygen to both furnaces was metered on a master meter

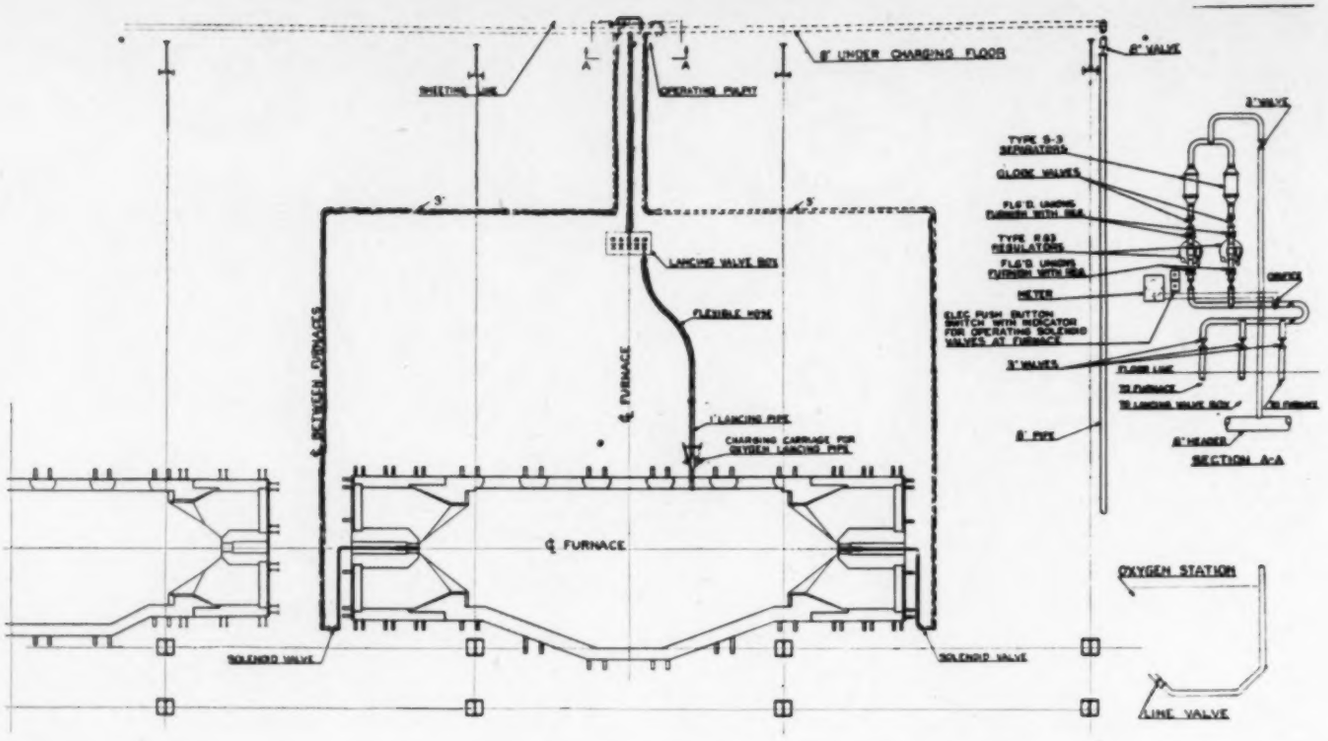


Figure 1 — General arrangement of piping on one open hearth furnace used in the oxygen tests.

of 300,000 cubic feet per hour capacity. The three orifice meters are of ring balance integrating and recording design using mercury as the sealing medium.

Burners — Figure 2 shows the burner design used on the first series of heats. This design had a complete circular opening for oxygen of 9.455 square inch area. Later seventy-five per cent of this opening was sealed up to give the oxygen stream higher velocity, leaving an area of 2.36 square inches at the bottom to serve as a nozzle. This design of burner was too complex in construction and was replaced by the combination gas and oil design, shown in Figure 3. This design allowed the use of two fuels; was of simpler construction; and had an oxygen nozzle under the oil pipe of only 0.719 square inches. When using oxygen at the rate of 47,000 cubic feet per hour, the oxygen pressure at the burner was 125 psi. This burner produced a flame of high luminosity and intensity, and was satisfactory on oil or a combination of oil and coke gas.

Lances and tripod — Figure 4 shows a lance in service on the tripod. One inch standard pipe twenty feet long has been the predominant size for this operation. Six to ten lances were used per heat, with a life that averaged about eighteen minutes. Occasionally a lance would last up to one hour when metallurgical conditions were favorable and floor traffic did not require a withdrawal. Total time per heat the lances were in the furnaces averaged two hours, with a range of from one and one half to three hours. A limited amount of experimenting was done with the surface jet, but it did not serve our purpose as well as the submerged lance. A solenoid pilot piston operated valve, with pushbutton control, was installed at each furnace on the line to lances to reduce the hazards connected with handling oxygen in hose and lance.

Furnace design — The splashing and iron oxide penetration caused by lance injection seriously impaired the furnace roof and backwalls. Refractory experience was so bad on the furnace with the five foot roof, as shown in Figure 5, that the design was changed to that shown in Figure 6. This design originally had a seven foot roof, but was raised to eight feet from sill plates to skewbacks. Uptakes were increased from 6 ft × 4 ft 6 in. to 6 ft 6 in. × 5 ft 9 in. and monkey walls eliminated entirely. Front walls were water cooled from the beginning of the experiment, but backwall cooling was recently added to improve the life of the very high backwalls. Both are of chrome brick construction.

Recent campaigns have not shown an appreciable improvement in roof life with the design changes. Additional thickness to roofs is being tried on the current campaigns, and results look encouraging. This change to the roof structure consisted of installing a section of 18 inch roof with 21 inch ribs over the center door, and 15 inch roof with 18 inch ribs over the two adjacent doors. This thickness extends from front to backwalls.

If this change in roof structure does not appreciably improve roof life other designs under consideration at present will be tried.

Some experimenting was done with two ¾ in. pipes, instead of a one inch lance, but splash was not reduced enough to warrant the additional inconvenience from charging floor traffic. A satisfactory method of introducing oxygen into the bath constitutes the number one problem being pursued at present.

Dust or fume, which was a by-product from the refining with oxygen and which will be discussed later, caused serious checker blocking. This condition has been greatly improved by increasing the vertical checker openings from 6 × 15 in. to 15 × 15 in.

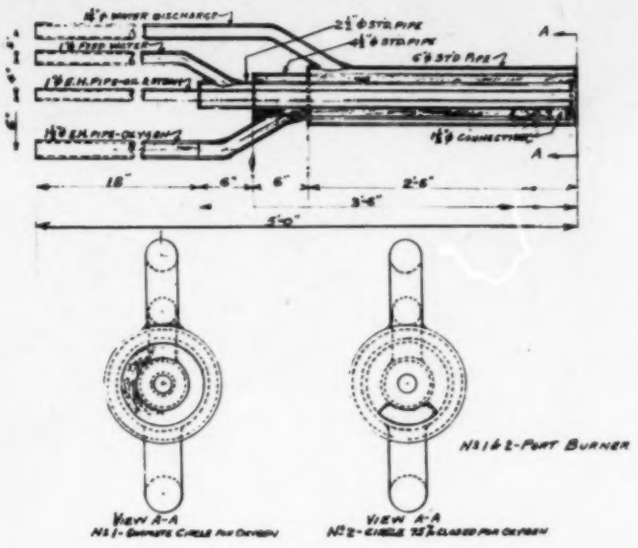


Figure 2 — The first series of heats used the burner shown in this sketch. It was found to be too complicated in design.

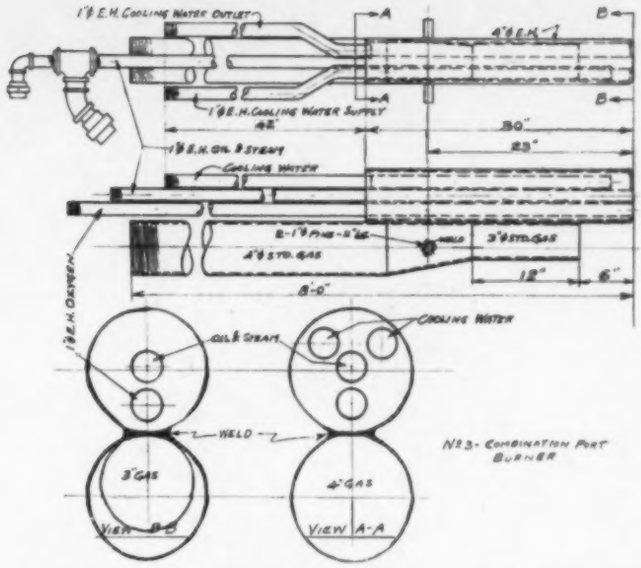


Figure 3 — The simpler burner shown in this figure replaced the design shown in Figure 2 and gave satisfactory service.

Operating practice — The practice in this plant was to charge heats of ratio 80 to 20, representing the ratio of the percent of hot metal to scrap. Sometimes due to shortage of metal or other conditions, the hot metal content was reduced, but when such conditions arose all furnaces were equally affected.

Table I shows a charge comparison of the average of three heats to be worked with oxygen compared with an average of five regular practice heats. The feed ore required to finish the regular heats is also included in the tabulation.

TABLE I

COMPARISON OF THE CHARGE OF OXYGEN AND REGULAR HEATS

	Oxygen	Regular
Carbon	0.07	0.06
Metallic charge — lb	434,780	446,900
Per cent metallic charge — hot metal	73.6	69.8
Per cent metallic charge — scrap	18.6	19.9
Weight of sinter charge — lb	46,800	50,800
Weight of limestone — lb	12,700	32,600
Weight of feed ore added — lb	None	18,600

The predominant fuel was No. 6 fuel oil, but some coke gas was used.

The practice up to May 1 was to commence using burner oxygen with the start of the charge of scrap, but at that time in order to conserve oxygen, the practice was changed to start the use of burner oxygen after the doors were banked. This practice did not melt down the scrap with sufficient speed, and was changed again to the present practice of starting the use of burner oxygen midway through the charging period. The rate of oxygen flow through the burners has been 30,000 to 40,000 cubic feet per hour from the beginning of the experiment. This quantity of oxygen permitted an increase in fuel rate while melting down by fifteen million Btu per hour to a maximum of ninety-five million Btu per hour.

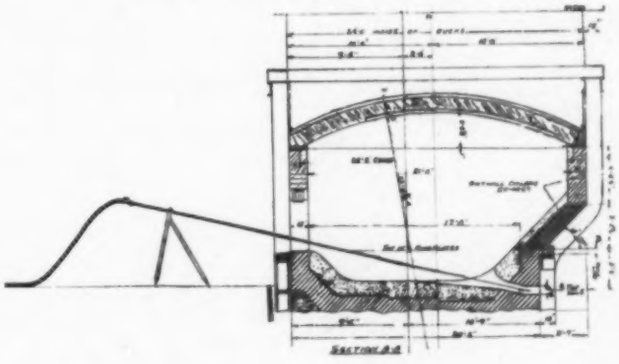
The use of lance oxygen was usually started shortly after the first flush, and the starting time was governed by experience experimentally acquired. Occasionally when conditions were favorable, the lancing operation was started directly after the addition of hot metal.

The normal rate for lancing use was 50,000 cubic feet per hour, but flows up to 100,000 cubic feet have been used by employing two lances.

Fuel is greatly reduced or shut off during the lancing periods. Burner oxygen is used as required to quickly restore and maintain temperature as fuel is turned on between lances.

Figure 7 shows the sequence of operation during a heat from charge to tap. On this heat 83,600 cubic feet of oxygen were used through the burners, and 121,200 cubic feet through the lance. Fuel was shut off for a total of one hour and fifteen minutes during lancing. Lance oxygen was started one hour and forty minutes from the finish of hot metal addition, and the first carbon analysis was made fifty-five minutes after lancing was started. The speed of carbon drop from 80 points carbon down was one point a minute.

Figure 4 — The average life of the lances was about eighteen minutes and the lances were in the furnace an average of two hours per heat.



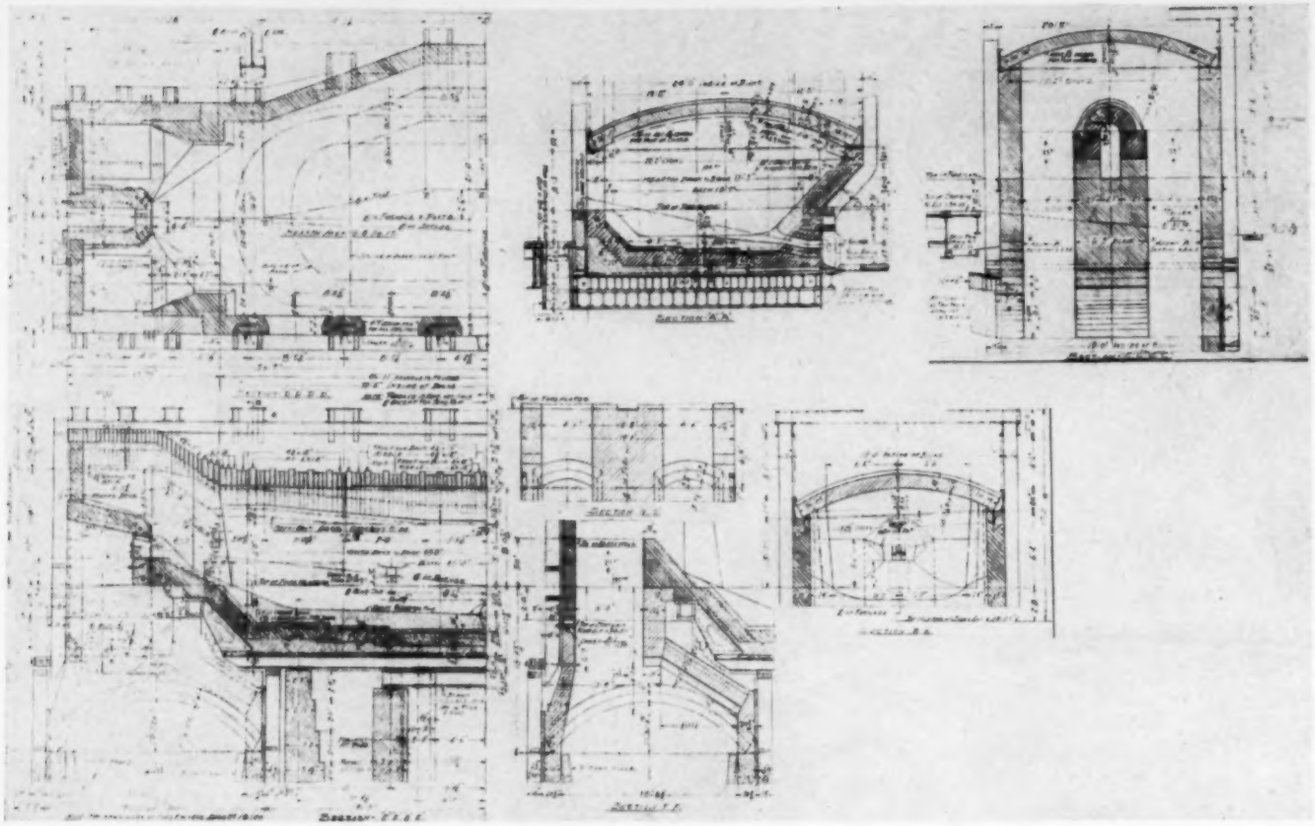


Figure 5 — Bad refractory experience was had with the furnace which had a five foot roof.

Figure 6 — Raising the roof height to eight feet from five feet did not appreciably help roof life.

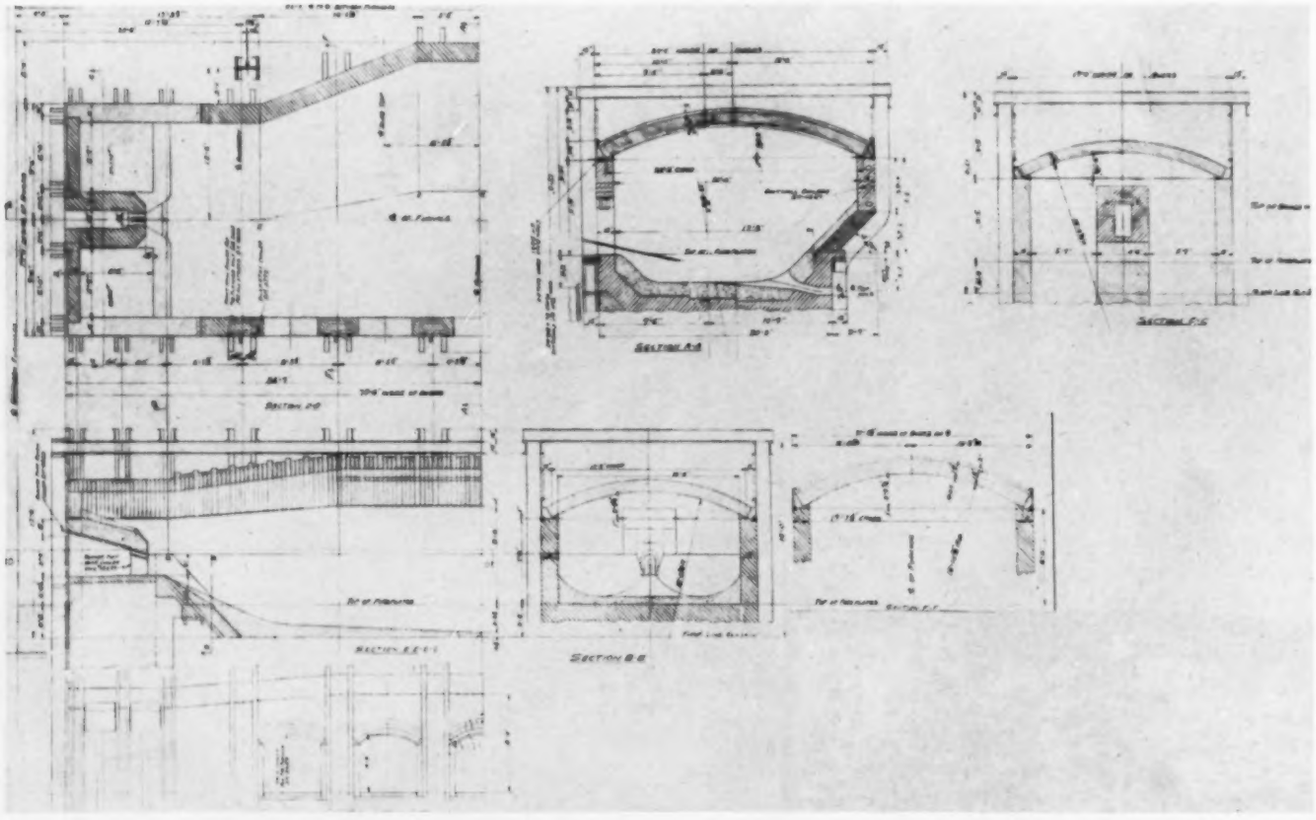


TABLE II

Operating Data on Typical Oxygen and Regular Heats

	Oxygen heats				Average five regular practice heats
Reference	A	B	C	D	E
Grade carbon	0.07	0.06	0.07	0.08	0.06
Total metallic charge — lb	424,960	437,560	433,300	433,490	446,900
Per cent metallic charge — hot metal	65.9	73.3	73.9	73.9	69.8
Per cent metallic charge — scrap	28.5	18.5	18.7	18.7	19.9
Charging time of scrap — hr-min	4–15	0–50	1–55	2–00	1–24
Elapsed time to finish of metal charge — hr-min	5–25	2–10	3–05	2–55	2–58
Time to finish heat after metal addition — hr-min	4–10	4–00	3–35	3–25	9–19
Total time required for heat — hr-min	9–35	6–10	6–40	6–20	12–17
Net tons produced per heat	193	198	183	191	207
Tons per hour (charge to tap)	20.2	32.1	27.4	30.2	16.8
Million Btu per net ton (charge to tap)	3,010	1,850	1,930	1,640	3,940
Total burner O_2 used during charging — cu ft	70,400	35,200	80,960	48,400	.....
Total burner O_2 used after metal addition — cu ft	110,900	48,400	13,200	23,760	.....
Total O_2 used in lances — cu ft	60,800	121,200	98,560	111,760	.....
Total O_2 used — cu ft	242,100	204,800	192,720	183,920	.....
Oxygen used per net ton of steel — cu ft	1,253	1,061	1,052	962	.....

Floor traffic required the withdrawal of a lance sometimes before it was burned up, but as mentioned previously, a heat will require 6 to 10 lances with an average life of eighteen minutes.

The difference in weights of sinter, limestone and feed ore, as represented in the two charges in Table I provided a comparison for computing the efficiency of lance oxygen use. This difference in weight amounted to 4000 pounds of sinter, 19,900 pounds of limestone and 18,600 pounds of feed ore. The oxygen available for oxidation from the three sources amounted to 8400 pounds or 99,200 cubic feet, compared with 110,500 cubic feet of lance oxygen.

Production — It has been proved that oxygen as used on these furnaces can increase production per hour up to 90 per cent, and reduce fuel consumption 50 per cent under regular practice. Monthly production and fuel consumption however have not been that impressive due to the amount of time the furnaces were out of service for brickwork, which was largely roof failure from splash and iron oxide penetration of the brick. Down time on the oxygen furnaces has averaged 42 per cent more than on the other furnaces, and this outage combined with the time penalty of the additional warm up periods on the oxygen furnaces resulted in considerable loss in tonnage.

Data as exhibited in Table II were taken from representative heats and show the results that can be accomplished by the use of oxygen as practiced in this plant. The greater portion of the benefits were obtained from the use through lances, but there was sufficient justification in burner injection to continue the burner use with discretion.

Comments on this chart include reference to the short time to finish a heat after metal addition, and high tons per hour and low fuel consumption on oxygen heats compared with regular practice. The low consumption of lance oxygen on the heat as tabulated under reference "A" was in all probability due to oxide formed by excess oxidation of scrap while waiting for hot metal. However, the use of lance oxygen finished this heat in good time after the metal addition.

Quality and yield — No difference has yet been detected on the quality, surface, or yield of oxygen heats as compared with regular practice. However, on a comparative test, twenty-five oxygen heats showed a drop of 0.008 per cent of sulphur between preliminary and final test compared with a drop of 0.005 per cent on the same number of regular heats. This tendency toward better sulphur removal in the oxygen heats should eventually be reflected in a better metallurgical practice.

Operating problems — Refractory life has already been discussed and is considered number one problem to be solved.

The number two problem was the fume emitted from the stack during lancing. The location of this plant, near a residential area made it imperative that the dust provled be solved. Considerable research was done on the orange red to chocolate red fume, and the analysis, as shown in Table III, covered the range of composition.

The fume is highly magnetic, and our researchmen have come to accept it as a ferro magnetic variety of ferric oxide, of which roughly 88 per cent is ferric oxide. Under the electron microscope the mean particle size was found to range between 0.115 and 0.183 microns.

The collection of this material before it escaped into the atmosphere became our problem. After experiment-

TABLE III

CHEMICAL ANALYSIS OF THE RED FUME

	Per cent
Iron (Fe)	61.3-61.8
Silica (SiO_2)	1.08-2.56
Calcium Oxide (CaO)	0.30-1.43
Magnesium Oxide (MgO)	trace
Carbon (C)	0.32-0.84
Sulphur (S)	1.10-1.64
Alumina (Al_2O_3)	0.23-1.92
Phosphorous Pentoxide (P_2O_5)	0.63-0.97
Manganese (Mn)	0.30-0.70

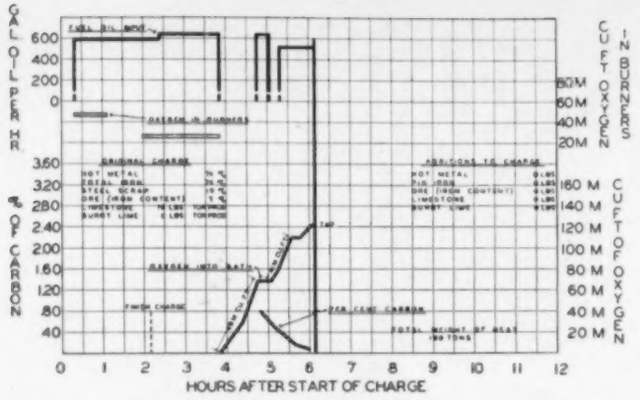


Figure 7 — Operating sequence in making a heat of steel with oxygen is shown in this sketch.

ing with a spray tower pilot plant of one sixth scale, which showed an efficiency of removal of 80 per cent, both furnaces were equipped with washers, as shown in Figure 8. These washers, with a consumption of 500 gallons of 200 pound pressure water per minute on each, are used only during the lancing periods and removed 85 per cent of the solids being carried by the waste gas. This efficiency of removal was not sufficient to eliminate all complaints from dust. Further experimenting was done with the venturi pilot washer of one fifth scale, shown in Figure 8 and tests showed a range of dust removal between 95 and 99.5 per cent when the venturi tube was used before and in conjunction with a pilot spray tower. The pressure drop of the waste gas through the low pressure water flooded venturi tube was 14.8 inches of water pressure, and when combined with the spray tower required a total head of 16 inches of water pressure to overcome the friction. The pressure drop over the existing washers is 4½ inches of water pressure, and new fans and 210 hp turbine drives are to be installed to replace existing fans and 135 hp motors. After these improvements are made, the fume emitted during lancing should no longer constitute a nuisance to the community.

Figure 9 shows the Research Corporation design apparatus used for determining the weight per cubic foot of dust entering and leaving the washers. The solids are collected in filter paper capsule, dried and weighed before and after a metered quantity of gas had been drawn through the apparatus. The entire determination was similar to testing the flue dust content of blast furnace gas. When using oxygen through the lance, the dust content of the waste gas entering the washers ranged between 1 and 6 grains per cubic foot, corrected to 60 F; the highest dust content being from the first lances used on each heat. The average dust content was 2.6 grains per cubic foot corrected to 60 F. No attempt has yet been made to reclaim the solids washed out of the gas in the scrubbers, but they amount to about 1000 pounds per heat.

Conclusion — During the nine months of operation on oxygen, certain opinions have been formed and some definite conclusions have been reached. A summary of these follows:

1. The future policy of Republic Steel Corporation concerning the use of oxygen has not yet been determined.
2. The use of oxygen in the open hearth to enrich the air for combustion and eliminate carbon from the bath definitely will shorten the time of making a heat of steel and reduce the consumption of fuel per unit of production.
3. When using a ratio of hot metal to scrap of 80 to 20,

Figure 8 — Washers were used which removed 85 per cent of the solids in the waste gas.

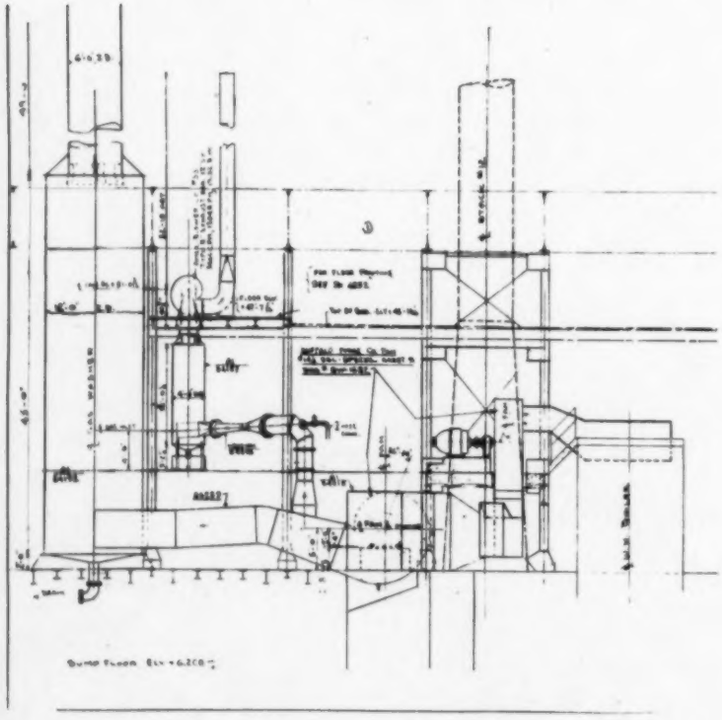
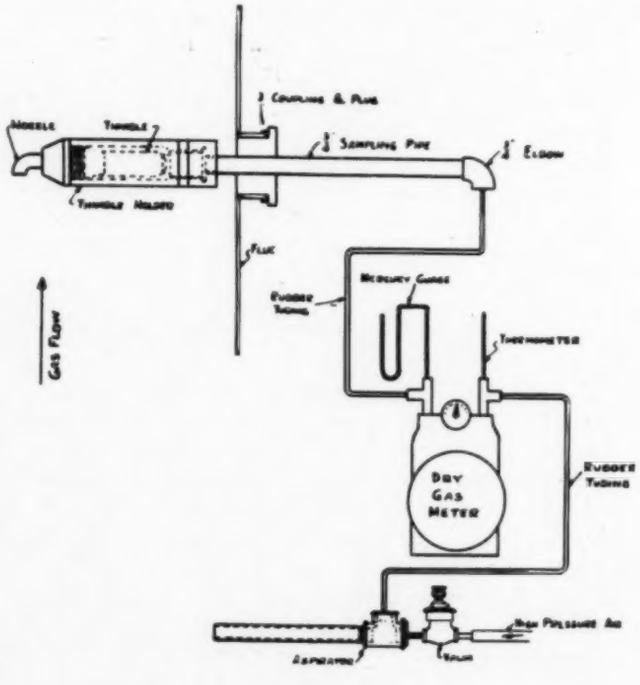


Figure 9 — This sketch shows the apparatus used to determine the dust entering and leaving the washers.



the greatest benefit of using oxygen is derived by injection into the bath to eliminate carbon.

If charging conditions permit taking full advantage of fast melt-down, the advantage from bath injection as compared to that from burner use diminishes as the proportion of hot metal decreases.

4. The use of burner injected oxygen definitely increased the luminosity of the flame and promoted quicker melt-down of the scrap.
5. The use of oxygen enriched air introduced through the checkers does not produce flame characteristics equal to burner injection.
6. A better means must be found to introduce oxygen into the bath and attain longer roof life.
7. The discharge of dust from the stack while using the oxygen lance can be eliminated by water scrubbing.
8. Oxygen of lower purity could perhaps be used advantageously.

The following benefits from the use of oxygen in the open hearth may be obtained:

1. An improved furnace design.
2. Total or partial elimination of checkers.
3. Higher over-all furnace efficiency.

DISCUSSION

PRESENTED BY

G. V. SLOTTMAN, Air Reduction Sales Company, New York, New York

E. T. W. BAILEY, Steel Company of Canada, Ltd., Hamilton, Ontario, Canada

A. G. E. ROBIETTE, John Miles & Partners, Ltd., London, England

E. C. McDONALD, Combustion Engineer, Republic Steel Corporation, Cleveland, Ohio

J. N. HORNAK, Carnegie-Illinois Steel Corporation, Homestead Works, Munhall, Pennsylvania

S. D. RAND, A. M. Byers Company, Ambridge, Pennsylvania

G. V. Slottman: From Mr. McDonald's paper, I notice that he is working in the very high carbon ranges. We have experienced a lot of blowing of slag in high carbon ranges because the carbon reacts with the oxygen at the point of emersion of the carbon in the bed.

In the low carbon ranges, increasing amounts of oxygen go into the bath to form iron oxide, which is diffused broadly through the bath, with the result that the seat of activity of the decarburization reaction is spread out over a broad area.

It seems to me that in attacking this problem of decarburization in the very high carbon ranges, we should find some way of spreading the activity out over the bat.. so that it is not localized at the seat of injection. The work which was done at the Allegheny Ludlum Steel Corporation last July and August, 1946, indicates that refractory life when working in low carbon ranges is considerably greater than in normal ore practice, and that the problem of excessive refractory wear is peculiar to the high carbon region.

In conclusion, I would like to point out that the actual work which was illustrated was very interesting, in that they are still using consumable lances, such as were first developed for open hearth work.

E. T. W. Bailey: Mr. McDonald has given us a very practical description of actual production experience especially where oxygen is used to reduce carbon in the bath. He clearly shows there is still lots of research work yet to be done especially in connection with the use of oxygen for carbon reduction.

A. G. E. Robiette: I would like to ask if the author would like to make any comments as to the effect of oxygen on the yield.

E. C. McDonald: We have found no difference in the yield, quality, or surface of oxygen heats when compared with regular practice.

J. N. Hornak: At our plant, the yields are not figured for individual heats but are calculated for all the furnaces in each of the shops. We have concentrated our efforts on the use of oxygen and have not paid too much attention to the yield. However, as in Mr. McDonald's case, we have not noticed any apparent detrimental effect on the yield when heats are agitated with a gas.

A. G. E. Robiette: I think the gentlemen who replied to my question did not quite appreciate the point I was making, that is, if you use ore with pig iron and scrap you will get more ingots than if you use pig iron and scrap and oxygen. That is obvious, and I would like to know whether they have any figures as to the weight of ingots with oxygen as opposed to using iron ore as the oxidizing medium.

E. C. McDonald: I understood the question as referred to yield and again answer we have found no difference between oxygen and regular practice. Apparently the question pertains to the relative size of oxygen and regular heats when using the same amount of iron and scrap. We have found no difference in the size of the finished heats and attribute this to the larger iron loss in the increased slag volume in regular heats.

I have also discussed the fume loss. It is large during the lancing periods, but it is also quite large on regular heats but spread over more hours. Again I say we have found no difference in yield.

J. N. Hornak: In the ore addition, you have probably a ton or two of iron, and it has to be figured into the economy. The increase in production rate that we are talking about is an increase of 15 to 30 per cent. One or two tons divided over a seven-hour period is merely a fraction of a ton. As I said, the ore addition has to be figured in the economy as to whether oxygen will justify itself or not.

S. D. Rand: We have used a lot of oxygen in our electric furnaces, even to the extent of taking the ore entirely off the floor, but we have encountered a sharp rise in sulphur content after the use of oxygen as compared to what we had before. I wonder if anybody can explain that to me. We have worked with it for months and have not been able to do anything about it with an ordinary pipe lance injector.

Modern Coal Handling System Important Unit in Lorain Expansion

▲ COKE making capacity at the Lorain works of National Tube Company in Lorain, Ohio, has been increased to a total of 1,650,000 net tons annually by the addition of new coke ovens with an annual capacity of 800,000 net tons, Figure 1. The improvements include enlargement and modernization of coal and coke handling facilities, the construction of three new coke oven batteries of 59 ovens each and numerous changes to facilities for recovery of coal chemicals.

Among other improvement and expansion projects either completed or under way at the Lorain plant, in addition to enlargement of coke production facilities, are the construction of an entire new bessemer steel making plant replacing the existing plant; the installation of a new blooming mill, bar mill and billet mill to replace two existing blooming mills and a combination rail mill; a new continuous seamless tube mill; concentration of butt weld pipe making and pipe galvanizing facilities at Lorain works; and other major improvements including a new, three acre warehouse.

Simultaneously with enlargement of facilities for making coke and coal chemicals, the problem of increasing stocking devices, storage facilities and coal preparation and handling equipment arose. In brief, this problem was solved by the installation of a rotary car dumper which is capable of handling 30 cars per hour and is expected to handle 20 cars per hour under normal operating conditions, replacing unloading methods which formerly could handle only 65 cars in 8 hours. The number of available mixing bins has been increased so that the coal handling system can blend four types of coal instead of two as formerly. Gravimetric mixers were installed for the crushing of coal replacing volumetric mixers previously used.

High and low volatile coals from mines owned by the United States Steel Corporation furnish the bulk of the coal for producing coke at Lorain works. With the new coke ovens at normal operating rate, approximately 6300 tons of coal per day will be handled. Normally the coking coal mix is made up of equal amounts of high and low volatile coals.

Figure 1 — Belt conveyors for carrying coal to the storage bin of the three new coke oven batteries at the Lorain works of National Tube Company. The new ovens at this United States Steel Corporation subsidiary plant have a combined annual capacity of 800,000 net tons. The concrete storage bin spans the new batteries of ovens.

COKE AND COAL STORAGE YARD

Space for storing coal and coke is provided between the concrete walls that carry the tracks on which the coal bridge operates. Maximum storage capacity, with all spaces filled, is 261,120 tons of coal, 27,000 tons of coke, 15,000 tons of coke braize and 5000 tons of steam coal. This storage capacity was provided by extending the former storage space a distance of 600 feet. Total length of the storage yard is now 1,708 feet. Width between bridge walls is 215 feet. Stock piles can attain a maximum height of 53 feet. Nominally the space for storing coal is set up for separate storage of 125,000 tons of high-volatile coal and 100,000 tons of low-volatile coal, in addition to the quantities of coke, braize, and steam coal mentioned above.

COAL-HANDLING SYSTEM

The entire coal-handling system is designed to provide for segregated stocking, handling and blending of a maximum of four separate types of coal, Figure 2.

Under the modernized arrangement, the storage area is served by two 48-inch reversible conveyors leading from a by-pass gate near the center of the south side of the storage area. A mechanical conveyorized stacker operates in conjunction with each conveyor.

According to the class of coal they contain, the cars are dumped by the new car dumper into one of four bins at the new unloading station. Each of these bins is equipped with a vibrating type of feeder that takes coal from the bottom and discharges it onto a 48-inch belt conveyor that connects with another conveyor of the same size leading to a surge bin at the coal breakers. Individual belt feeders, 36 inches wide, transfer coal from the surge bin to each coal breaker. By means of by-pass gates, it is possible to direct coal from the car dumper bins to another 48-inch conveyor running to a bin at the stocking area. This bin is equipped with by-pass gates leading to hinged chutes which direct the coal onto either of the two reversible 48-inch conveyors that each cover approximately half of the length of the stocking area. The chutes are lowered when coal is being discharged onto the conveyors for stocking, and raised to clear coal traveling on the belt when its direction is reversed for reclaiming. The mechanical stackers remove the coal delivered by the reversible conveyors and deposit it on the proper stock pile.

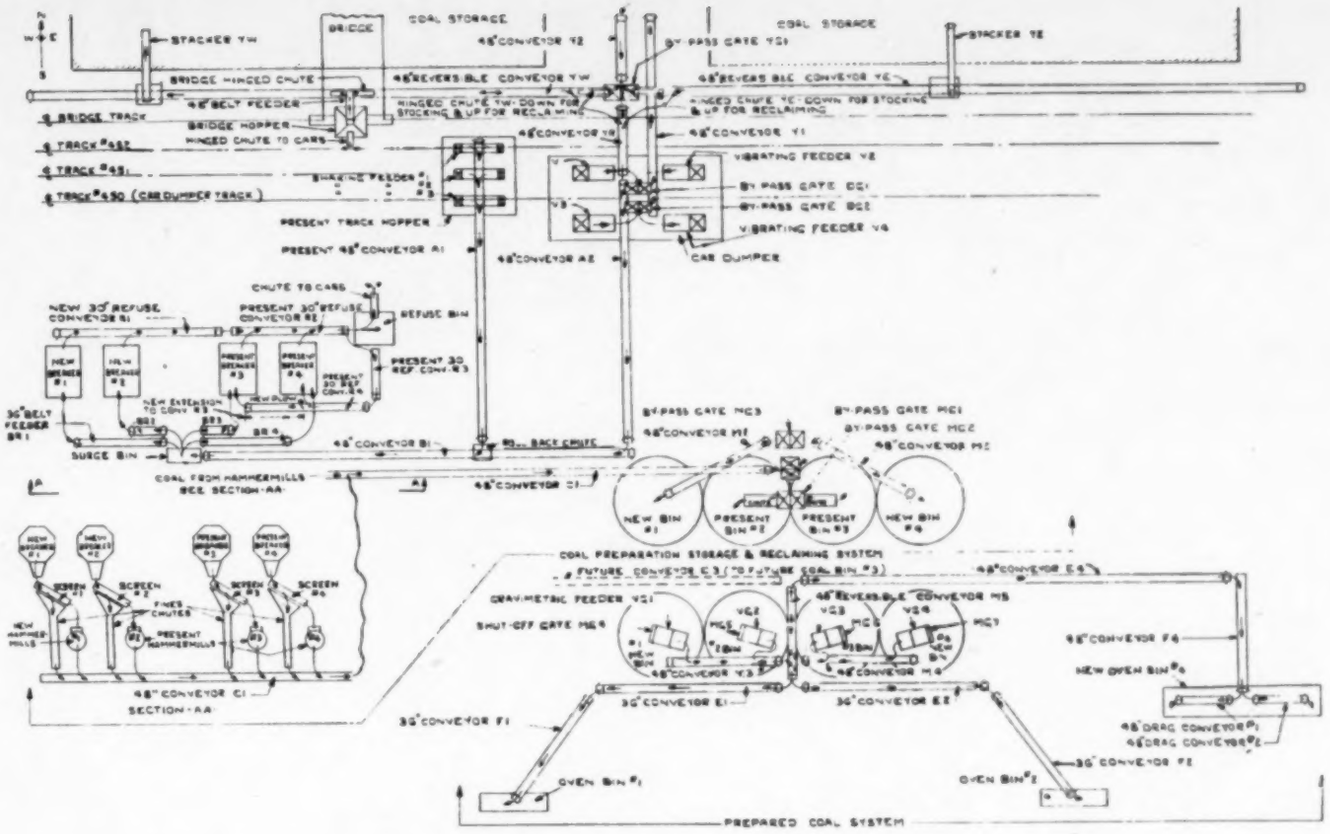


Figure 2 — Diagrammatic layout of the enlarged coal stocking, handling and mixing equipment for the coke plant.

Coal reclaimed by the coal bridge from the stock piles is dumped into the bridge hopper, from which it is discharged onto a 48-inch conveyor which transfers it to the reversible stocking conveyors that return it to the main handling system. Railroad cars on one of the three tracks leading to the old-type track hoppers (to be mentioned later) can be loaded from the bridge hopper by a hinged chute.

Conveyor capacities of 500 tons per hour, formerly used in the coal handling system, have all been increased to equal the 1200 tons per hour maximum capacity of the new conveyor systems installed to handle with greater dispatch the increased tonnage of coal required by the expanded coke plant.

COAL CRUSHING

The coal that goes directly from the car dumper through the coal breakers is discharged onto shaker screens having individual capacities for screening 400 tons of coal per hour. These permit undersized coal to by-pass the hammer mills succeeding the breakers, and feed directly into the storage conveyor leading to the mixer storage bins for crushed coal. Refuse materials from the breakers is discharged onto 30-inch conveyors that carry it to a refuse bin from which it is loaded by chute into railroad cars for disposal. Other 30-inch conveyors make it possible to by-pass the refuse bin and return material to the breakers for reprocessing, if desired. Only two of the breakers are employed for such work. The coarse coal passes through hammer mills, which are of the reversible type, the final crushed coal being of such size that 85 to 90 per cent will pass through a $\frac{1}{8}$-inch screen. The coal breakers, screening tables and hammer mills are operated under a partial vacuum as part of a dust recovery system that eliminates coal dust from the area surrounding the operations.

Crushed coal from the hammer mills is discharged onto a 48-inch conveyor that carries it to the proper one of four mixer bins, each of 500-ton capacity. These four bins are installed side by side in a straight line, Figure 3. Routing of the coal to the proper bin is effected by means of by-pass gates which direct the crushed coal into either of two chutes leading to the two center bins, or onto either of two 48-inch conveyors that lead to the two outside bins.

GRAVIMETRIC BLENDING

One of the most important advances in coal handling and preparation in the new coke plant procedure has been the adoption of gravimetric rather than volumetric blending: that is, coal for blending is weighed instead of measured by volume. By taking steps to prepare the coal delivered to the mixing bins so that it will have a uniform bulk density, it is possible to blend coals very accurately by weight proportions using the gravimetric feeders, Figure 4. Each of the feeders is furnished with a weigh belt that permits the continuous indication and recording of the weight of material passing over it.

The gravimetric feeders from the two left-hand bins

discharge onto a 48-inch conveyor running from left to right, while the two right-hand bins discharge onto another 48-inch conveyor running from right to left. Both of these conveyors carry the coal to a mixer box, from which the coal is discharged and picked up by a 48-inch reversible conveyor that carries the coal, in one direction, to the 48-inch conveyor leading to the storage bin of the three new batteries of ovens, and in the other direction, to either of two storage bins for the older batteries served by 36-inch conveyors.

The storage bin for the three new batteries of ovens has a gross capacity for 4000 tons of prepared coal, and a net operating capacity of 3500 tons. It is built in five bays, with one row of hoppers. A 48-inch drag conveyor over the bin conveys coal toward each end of the bin at the rate of 500 tons per hour in each direction, or a total of 1000 tons per hour distributed over the entire bin (conveyor speed about 100 feet per minute). The original storage bins have capacities of 2800 and 1800 tons.

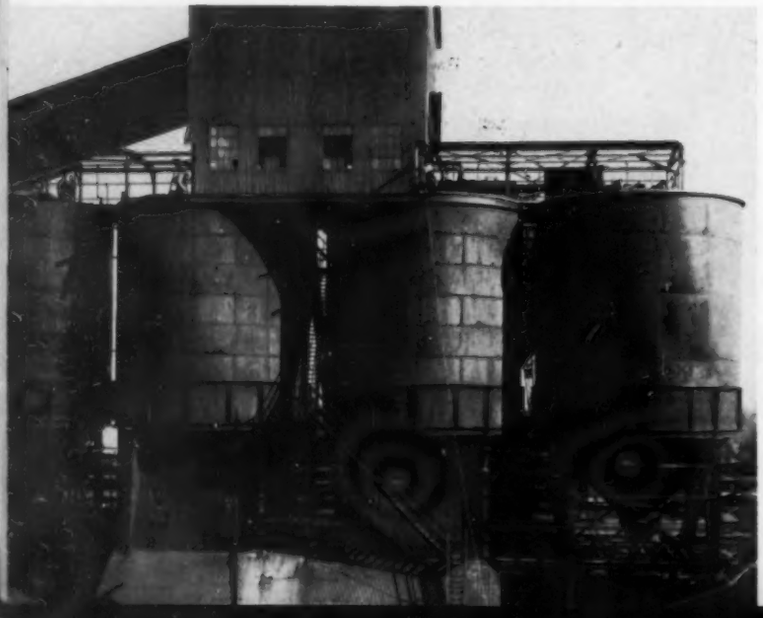
Each coal storage bin spans the batteries it serves. The larry car (coal charging car) picks up coal from the bins through chutes, and transfers it to the particular oven to be charged.

COAL CHARGING CARS

While not specifically a part of the coal-handling system, actually being considered a part of the oven equipment, the coal charging cars of the new batteries are of a special design, and contribute to achieving maximum benefit from the improved handling and blending procedures.

Instead of gravity feed of coal from the charging cars into the new ovens, each of the three new batteries is charged by a coal-charging car having a capacity for handling sufficient coal to meet the requirements of the 13.3 net ton capacity ovens. Each car has three cylindrical hoppers, corresponding to the three charging holes of the ovens, and is fitted with a revolving table delivery mechanism at the bottom of each hopper. Mechanism

Figure 3 — Coal mixing bins in the coke plant at the Lorain works of National Tube Company. Each bin is equipped with a gravimetric feeder that functions to assure accurate blending of coals for coking.



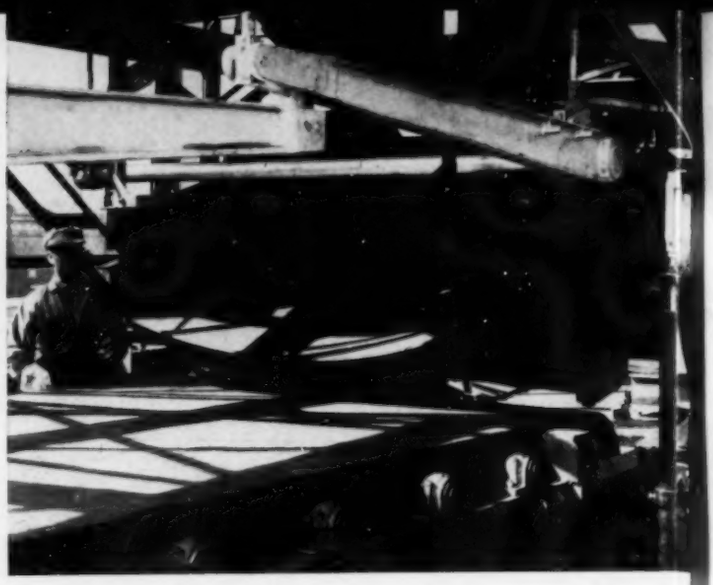


Figure 4 — Vibrating type unit forming part of the gravimetric feeding system in the coal mixing building at the coke plant of National Tube Company's Lorain works, in Lorain, Ohio. The new mixing facilities are part of an expansion program that has increased production of coke at this plant by 800,000 net tons annually.

is also provided on the car for operating the coal bin gates when charging coal into the car.

The revolving table feeder assures a controlled, regular feed of coal to the ovens through their charging holes and possesses numerous advantages over the older method of simply allowing coal to fall by gravity from the bins of the larry car into the oven at an uncontrolled rate. Hang-up of coal in the car is eliminated, coal is discharged from all hoppers simultaneously, and there is a lessened impact of coal, reducing the difference between the densities of the different parts of the charge (notably at the top and bottom of the oven). Also, the leveling operation is simplified by the uniformity of distribution of coal in the oven. Bridge speed of the loaded charging cars is 380 fpm, maximum; when empty, they can travel at speeds up to 420 feet per minute. Another feature of this type of car is that an interlocking control system makes it impossible for the feeders to operate unless the drop sleeves that guide the coal from the car to the charging holes have been lowered to proper charging position over the holes, thereby eliminating spillage of coal due to improper spotting of the car.

AUXILIARY COAL UNLOADING FACILITIES

To provide auxiliary coal unloading facilities for emergency use, the old track hopper system for unloading coal has been revamped and retained as standby equipment. Three railroad tracks provide facilities for unloading cars manually into the track hoppers at this unloading station, from which coal is passed by conveyor directly to the breakers. There are six pits, two underneath each track, each equipped with a shaker feeder that delivers coal to a 48-inch wide belt conveyor that discharges through a roll-back chute onto the 48-inch main-line conveyor that normally carries coal from the car dumper.

BASIC ENDS AND ALL-BASIC

Open Hearth Furnaces

. . . . the use of basic ends on open hearth furnaces indicates savings in the order of 10-25 cents per ton . . . . the use of the all-basic furnace, although experimental at present, indicates that further savings are possible . . . .

By DR. R. P. HEUER and MERVIN A. FAY
General Refractories Company
Philadelphia, Pennsylvania

▲ THE constantly increasing use of basic refractories which has characterized open hearth furnace construction during the past decade has now culminated in the operation of two experimental all-basic furnace installations, both of which are regarded as successful. Completely basic end structures for open hearth furnaces are also finding extensive use as a partial approach to the all-basic furnace. At present fourteen furnaces are operating with suspended basic ends and installations are definitely planned for fourteen more furnaces. These twenty-eight furnaces are scattered from Canada to Texas in fifteen different steel plants. Further installations of basic ends and all-basic furnaces are now pending.

The development of basic ends and the all-basic furnace has been pioneered by several steel producers in conjunction with several manufacturers.

The rapid progress of this development makes it worthwhile to review the achievement to date and to consider the position of basic ends and the all-basic furnace in the open hearth today and their probable position in the future.

DEFINITIONS

The all-basic furnace may be described as a conventional furnace with basic front walls, back walls, etc., to which a basic main roof and basic ends have been added. Basic ends may also be used with conventional silica main roofs and will be discussed separately, whereas the discussion of the all-basic furnace will revolve upon consideration of the basic main roof.

In order to clarify exactly what is meant by this differentiation, the end structure is defined as that portion of the furnace from the bridge wall to the end wall, from roof to pit, but not including the furnace fantails or regenerator chambers. Thus, any roof sections, sloping or otherwise, from the knuckles to the bridge walls are considered as part of the main roof and not as part of the end structures. By this definition the end includes only those furnace sections from which drippings or accretions would collect in the slag pockets.

The portions of a basic end which are built with basic brick include the roof above the burners and uptake wall sections down to a point in the slag pockets below which the temperatures are so low that the slag deposit does not react with clay or silica brick. This point is usually located within six feet of the floor of the slag pocket. In some cases, the basic brick extends all the way to the floor.

Mechanical support is provided for the basic brick in the port roof, the undercut chill wall and the end and side walls of the uptakes from the top of the fantail openings to the charging floor level. The construction of the fantail opening as a suspended nose section is not necessarily essential to a basic end, but is usually found desirable as a means of simplifying and improving construction.

In converting a furnace to basic ends, several desirable changes in design are permitted. The large arch across the slag pocket beneath the burner is no longer needed for support of the chill wall and can be raised to floor level or eliminated completely; wall sections can be made thinner, thus enlarging the uptakes; and complicated structures forming fantail openings can be simplified. Figure 1 shows a cut-away section of the end of a conventional silica furnace. Figure 2 shows this

Presented before AISE Detroit District Section Meeting, November 11, 1947

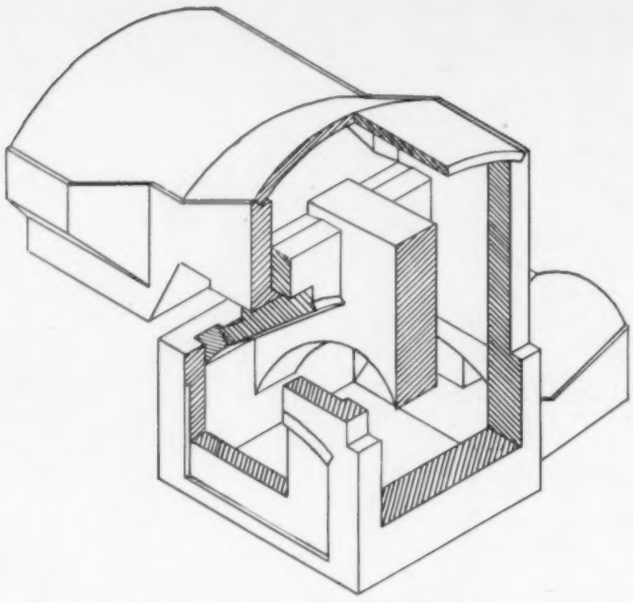


Figure 1 — Cutaway section of the end of a conventional silica furnace.

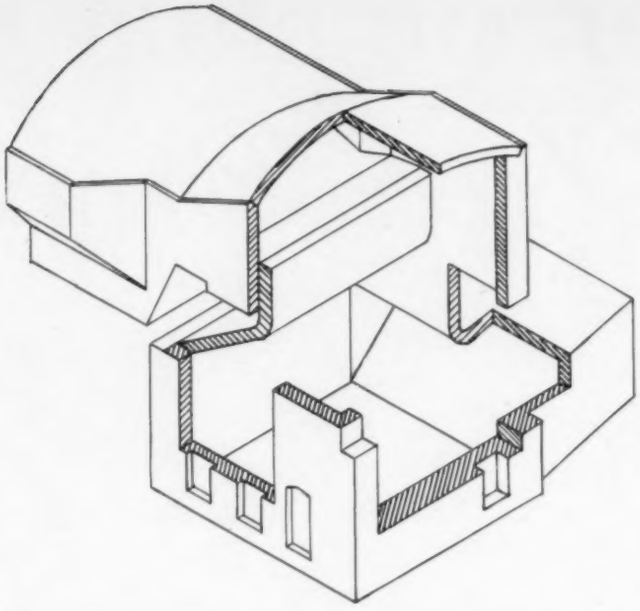


Figure 2 — Cutaway view of the furnace of Figure 1 if converted to basic construction.

same end as it could appear after conversion to basic construction.

HISTORY OF BASIC ENDS

The first complete basic end was built on one end of the 50-ton furnace at the Steel Company of Canada in Hamilton, Ontario, in January, 1943. This experimental installation was made in an effort to construct a furnace end with refractories which would not react with the furnace slags and dusts, thus producing a deposit in the slag pockets which could be removed easily. Only the port roof and the undercut chill wall of this furnace were of supported construction, but it was the forerunner of the present design. A friable slag deposit was obtained in the slag pocket and the end operated for almost 3000 heats before being dismantled.

Major repairs to the vertical walls were performed at 1510 and 2445 heats, respectively. Most of the supported brick in the undercut chill wall were still intact and in good condition when the furnace was dismantled.

This test was so successful that in May, 1944, the Steel Company of Canada installed a set of basic ends on a 180-ton furnace. Figures 3 and 4 show the construction of this furnace. A large part of the brick shown in Figure 3 is still in service in these ends, which have never been completely rebuilt and have now produced over 2145 heats. Repairs to the upper sections of the ends have occurred periodically and are best shown by the accompanying illustrations.

Figure 5 shows the deposit of slag in the slag pocket after 155 heats. It is friable and crumbly and can be removed easily by hand or mechanically. Figure 6 shows the slag pockets after cleaning at 253 heats. The small amount of wear on the brick and the absence of damage to the walls by the slag deposit is obvious. Figure 7 shows the uptakes, burner arch and port roof at the same time, 253 heats.

Figure 8 shows the first repair work required on these ends after 501 heats. The upper side walls in the unsuspended sections above floor level were patched. At this time an all-basic main roof was installed on the furnace and furnace production was speeded up by utilizing faster firing rates and higher furnace temperatures during meltdown. As a result, the wear on the basic ends was somewhat accelerated from this time on for the furnace.

Figure 9 shows the first major repair to the ends. The port roofs, burner support arches, and vertical walls down to floor level, were replaced. This repair was made after 832 heats. The brickwork left in was all at least nine inches thick; it had worn away less than three inches.

Figure 10 shows the repairs made to the ends after 1466 heats. This was the second major repair approximating a floor level rebuild.

Figure 11 shows the third major repair to the ends after 1813 heats. This repair was the first when any appreciable section of basic brickwork below charging floor level was replaced. The remaining brickwork from the original installation is still virtually as good as new, having worn away only about 10 per cent of its original thickness. From the appearance of these walls, it is

Figure 3 — Lower side walls of No. 16 furnace at the Steel Company of Canada.

impossible to even guess at the eventual life of these sections.

This last major repair at 1813 heats was made in May, 1947. Thus the repairs made to the ends of this furnace approximate only three charging floor level repairs in 1800 heats, and the eventual life of the construction as a whole is so great that it cannot as yet be predicted. This is to be compared with the operation of silica ends, including basic end wall panels, which must be rebuilt from below charging floor level upward every 300 heats and must be completely replaced about 2000 heats.

The second installation of a set of complete basic ends was made in October, 1944, at the American Rolling Mill Company at Middletown, Ohio. Figures 12 and 13 show the construction of this furnace. Many of the brick in this furnace are still in service after more than 1922 heats.

Figure 14 shows the chill wall after 1600 heats service. Virtually all the brick had been in service the whole time and are still in excellent condition. The most conservative estimate of their eventual life is 3000 heats.

The last repair, on this furnace at 1600 heats, was made in May, 1947. The furnace has since produced more than 322 heats without further patching. Thus, the repairs made were substantially three charging floor level repairs in 1600 heats and a fourth similar repair due at something over 2000 heats. Complete replacement of the brick structure probably will not have to occur before 3000 heats. This is to be compared with the operation of silica ends, including basic end wall and side wall panels, which must be rebuilt from several feet below the charging floor upward every 300 heats and replaced completely every 900 heats.

Since these first two installations, both the Steel Company of Canada and the American Rolling Mill Company in Middletown have embarked upon rebuilding programs for the conversion of more furnaces to basic ends. The Steel Company of Canada has built a second set, ordered a third, and plans the eventual conversion of two more 180-ton furnaces. The American Rolling Mill Company at Middletown, Ohio, has built a total of five sets of basic ends, and plans the conversion of their remaining three furnaces next year.

Figure 4 — Looking up uptakes of furnace shown in Figure 3.

Table I shows the present status of furnaces operating with basic ends and definitely planned construction.

THE EVOLUTION OF STRUCTURAL DESIGN OF BASIC ENDS

The furnaces described above show some of the changes which occurred in the development of the present basic end structure. The first such change was the addition of support to the lower end and side walls. The amount of suspension in this section has been gradually increased until the tiers of supported brick are now separated by only one course of conventional brick.

A further addition to the suspended wall portion of the end has been the inclusion of supported panels in the side walls immediately below the port roof skews and in the end wall at the same level. This was done to permit patching of unsuspended basic brick in the end

TABLE I

List of Basic Ends and All-Basic Furnaces

Company	Plant	All-basic furnaces installed	Basic ends installed	Basic ends ordered	Basic ends planned but not ordered	Totals
American Rolling Mill Company	Ashland, Kentucky	..	1	..	..	1
American Rolling Mill Company	Middletown, Ohio	..	5	1	2	8
Bethlehem Steel Company	Johnstown, Pennsylvania	..	..	1	..	1
Carnegie-Illinois Steel Corporation	Gary, Indiana	..	..	1	..	1
Carnegie-Illinois Steel Corporation	Homestead, Pennsylvania	..	1	..	..	1
Carnegie-Illinois Steel Corporation	South Works, Illinois	1	..	1	1	3
Central Iron & Steel Company	Harrisburg, Pennsylvania	..	..	1	..	1
Granite City Steel Company	Granite City, Illinois	..	..	1	..	1
Ford Motor Company	Dearborn, Michigan	..	1	..	..	1
Jones & Laughlin Steel Corporation	Cleveland, Ohio	..	..	1	..	1
Laclede Steel Company	Alton, Illinois	..	1	..	..	1
Lukens Steel Company	Coatesville, Pennsylvania	..	1	..	..	1
Sheffield Steel Company	Houston, Texas	..	1	..	..	1
Steel Company of Canada	Hamilton, Ontario	1	1	..	3	5
Youngstown Sheet & Tube Company	Youngstown, Ohio	..	1	..	..	1
		2	13	7	6	28

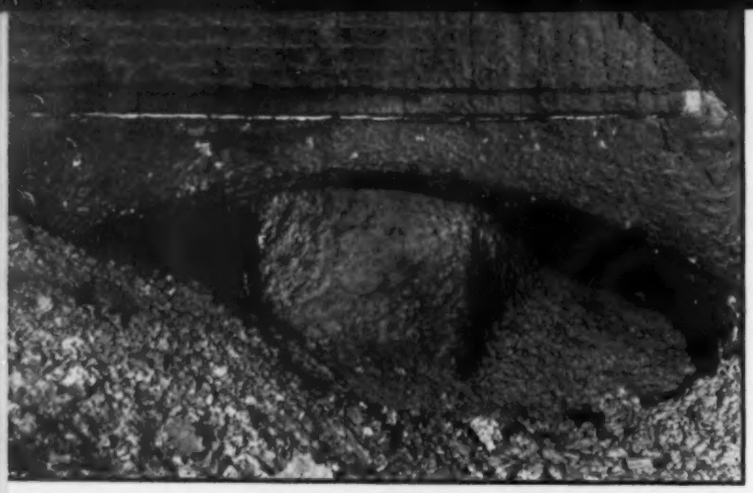


Figure 5 — The slag pockets of the No. 16 furnace at the Steel Company of Canada had these deposits after 151 heats.

wall and side wall panels at brick wall level without disturbing the good brick at higher locations in the walls.

The addition of the suspended fantail nose was a simplification of the structure which has virtually eliminated repairs to this section and fits in ideally with the use of unsuspended fantail and checker chamber roofs.

The design described uses suspension where refractory life is long and uses unsuspended panels where refractory life is relatively short. This is done so that long lived sections are independently supported and are not dependent upon more rapidly wearing furnace sections for support.

The changes of port roof design have been coincident with the development of the present main roof design and are discussed later in that connection.

The evolution in design of the support arches beneath the burners has been one of gradual elimination. The initial change in converting a silica end structure to a suspended basic end eliminates the structural necessity of this arch in that the chill wall is suspended. The only function of this arch in a suspended basic end has been one of supplying support for the burner and dog house structure. The early furnaces included basic burner support arches of the same width as those in silica furnaces but in more recent furnaces these arches have gradually been narrowed to increase uptake openings until three furnaces have now been built or designed eliminating this arch completely. Two other plants are planning to try artillery type burners to permit this change. On following a program of this sort, the American Rolling Mill Company has shown decided improvements in fuel rates and decreased wear of end refractories. It is definitely known that if gas velocities are slowed in the uptakes, the life of the walls is materially increased. It seems likely that elimination of this arch would yield several benefits.

Another structural change of importance has been the development of a sealed expansion joint. In the early constructions, expansion allowances were made by means of wooden spacers which burned out. This practice permitted excessive air infiltration during the early portions of the campaigns of these furnaces. A sealed joint was achieved using a corrugated metal plate as a spacer. The outer two corrugations are troweled full of a compressible packing material, such as expanded mica, and the inner face of the joint is pointed with chrome cement. This arrangement provided ample room for expansion and effectively cuts off air infiltration.

CHANGES IN BRICKS USED IN BASIC ENDS

The earliest basic ends were constructed with a chrome-magnesite brick developed especially for service in suspended basic main roofs. These brick are still preferred in roof sections, but subsequent trials of magnesite-chrome bricks in unsuspended wall panels gave record life in some furnaces so that the magnesite-chrome brick are now used in all wall sections. The suspended sections of such walls may be laid up with alternate magnesite-chrome and unplated brick, horizontally and vertically, in a checker board pattern, thus including one thickness of metal plate in each joint. The unsuspended sections of the walls are built with all magnesite-chrome brick and include sheet steel tie plates attached to the furnace steelwork inserted in some of the bed joints, to prevent buckling of the wall.

Other bricks have been tried in basic ends, but to date the chemically-bonded chrome-magnesite brick have proved most successful. Burned brick have been definitely proved unsatisfactory for service in the slag pocket wall sections, because of their spalling characteristics.

Another brick development which has contributed materially to the success of basic ends and roofs has been a socket which consists of a molded recess in the end with one side of the brick enclosed by a metal clip, as shown in Figure 15. This metal clip is pressed integrally with the brick and extends into the brick body to a depth of 2 to 3 inches. The recess accommodates the cast hanger used for support. Previous designs for suspended brick used a socket molded in the refractory body. This socket required the hanger to be imbedded in the body of the brick about 2½ inches from the cold face. This socket weakened the brick and prevented the utilization of the full thickness of refractory. The new socket corrected these conditions by presenting the utmost thickness of refractory for utilization, and actually reinforced the brick making it strongest in the socket section. This latter point is most important for bricks used in suspended nose sections where the brick hang from the smallest brick cross section. In addition to these features, the socket places the hanger in a position at the extreme end of the brick where it remains cool and is less liable to oxidation from overheating.

ADVANTAGES OF BASIC ENDS

The chief advantages of basic ends over silica ends are:

1. Decreased refractories costs.
2. Increased steel production.
3. Overall economy.

Decreased refractories costs for materials and labor

result from the extremely long life of basic ends. The smaller amount of brick required for the structure and the comparatively small amount of bricks used for replacements, more than outweigh the higher unit costs of basic refractories.

Because of the use of thinner walls and the use of smaller burner arches or even no burner arch at all, the total brick count for a basic end will be only about 50 to 60 per cent as great as that of a conventional silica end.

The life of the various basic end sections has averaged as follows:

1. Port roofs — from 500 to 1000 heats.
2. Walls above floor level — from 300 to 800 heats, depending upon the severity of furnace operation.
3. Walls below floor level — indefinite — some sections may require patching before 1000 heats, but the bulk of this part of existing basic ends has never been touched.

The life figures quoted will vary with the severity of the furnace operating conditions. Basic ends will last longer on furnaces easy on silica than they will on furnaces hard on silica ends. However, in any case, the refractory life of the basic brick is sufficiently long to justify their use.

The labor saving resulting from the use of basic ends, both in costs and in man-hours, is of greater magnitude than the materials savings. The initial labor saving results from the use of only about one-half as many brick equivalents in the basic end structure.

The long life at the refractory walls also drastically decreased the amount of labor needed for repairs.

Another labor saving feature of basic end construction is the ease with which the structure is laid up and the ease with which repairs can be made. The structure is made up of independent units each taking prescribed brick in prepared locations. Virtually no brick cutting is necessary and the bricklaying becomes a mere fitting together of the bricks. It has been found that apprentices lay up basic ends with facility equal to that of experienced masons. Another advantage of the supported walls is that patching of small areas can be accomplished without disturbing adjacent sections.

In view of the small amount of repairs made, the savings in general labor for teardowns are obvious. Major savings of general labor are achieved also by virtue of the ease of slag removal from the pockets of basic end furnaces.

The characteristics of the slag collected in the slag pockets of basic ended furnaces are unique. Unlike the fused mass of slag normal to a silica furnace, this slag is porous and crumbly, readily breaking up to granules. It is not wet or sticky when hot, but retains its friable character. The reason for this is that the slag does not react with the basic refractories which make up the end structure. No blasting or prying with a large beam is required to break the slag loose. It can be handled readily by pick and shovel, either hot or cold, or is easily handled with mechanical equipment, thus effecting further labor savings.

These savings in labor give lower costs and in addition, decidedly fewer man-hours of labor to perform equivalent jobs. This latter feature is of particular importance at the present time, in view of the existing shortages and high cost of labor.

Increased furnace production from basic ended furnaces has resulted principally from the increase in furnace operating time by virtue of the decreased repairs. In most cases, repair and rebuilding time has been decreased by more than 25 per cent after installation of basic ends. Furnace production has increased accordingly.

Some increases in operating rates also have been achieved by some operators of basic end furnaces. However, it seems likely that substantial increases in production of this sort can be obtained only on furnaces with restricted uptakes which can be enlarged by the use of suspended basic ends. On furnaces with uptakes sufficiently large to supply all the requirements for proper combustion, it is questionable as to whether increase in operating rate could be obtained from the use of basic ends.

Other causes of increased furnace production are largely intangible but important. One of these is the better scheduling of operations, made possible by the decreased repairs and the absence of hot repairs. It should be remembered that all repairs can be done coincident with main roof repairs. Regular roof repairs are required at normal frequency and present periods during which virtually all repairs can be made to end sections without additional furnace delay. Such intangible factors can contribute materially to increasing furnace output.

The overall result of these things affecting furnace output is a total increase in furnace production which has been measured at the Steel Company of Canada and at the American Rolling Mill Company as being about 5 per cent. Such an increase is well worthwhile in these times of steel shortage.

Besides the decreased refractories material and labor cost and the increased furnace production, there are other factors which contribute to the overall economy of basic ends. One of these is the value of the slag deposit collected in the slag pockets of a basic ended furnace. It consists almost entirely of iron oxides, as shown by the analysis in Table II.

The collected material contains about 50 per cent metallic iron. It is suitable for use as charge ore in either the open hearth or blast furnace. Inasmuch as

Figure 6 — The slag pockets after cleaning at 253 heats appeared as shown in this photograph.

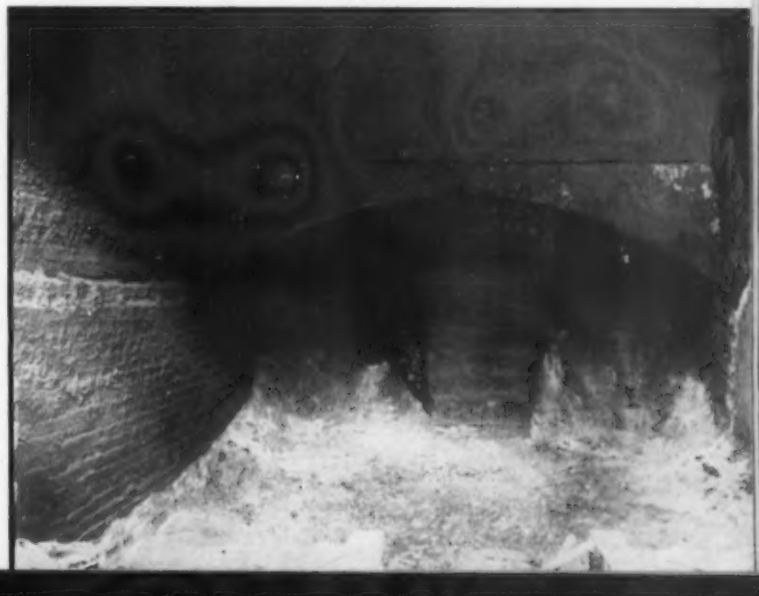


TABLE II

TYPICAL ANALYSIS OF SLAG DEPOSITS FROM BASIC END FURNACES

	Sample A	Sample B	Sample C
	Average deposit, per cent	From near sand bottom, per cent	Icicle on end wall, per cent
Iron Oxides	85.01	74.46	87.59
SiO_2	2.64	7.68	2.28
Al_2O_3	1.32	1.78	1.48
CaO	3.04	4.21	4.10
MgO	3.10	4.42	2.28
Cr_2O_3	2.17	2.96	.....

this material is lost completely when silica ends are used, a credit to the basic ends should be made for the amount of slag collected at average ore cost for the particular plant involved.

The combination of decreased refractories costs, decreased labor costs, increased furnace production, and other savings is remarkable overall economy. This is best illustrated by cost data on a typical basic end installation on a 180-ton furnace.

Table III shows installation and repair costs for the conversion and operation of furnace ends with basic construction as compared with normal silica construction. This shows that the installation of a set of basic ends costs about $40,000 more than a complete silica rebuild. However, when a complete replacement of the basic end structure is necessary, it costs only about $12,000 more than a complete silica rebuild, because many of the initial conversion costs are not repetitive.

On new construction, the installation of basic ends costs considerably less than conversion to basic ends at some later date. The initial cost of basic ends on a new furnace is only about $25,000 to $30,000 more than a conventional silica furnace.

Individual repair costs with basic ends are liable to be about the same as or greater than equivalent silica repairs, but they occur at less frequent intervals. A typical operation with basic ends is a minor rebuild after about 450 heats and a floor level repair after about 900 heats repeated in sequence. Typical operation of silica ends to be compared with this is a sequence of floor level repairs at 300 heat intervals, and complete rebuilds at 900 heat intervals. Costs of these various jobs are all shown in Table III.

Table IV shows the average rebuilding times required for repairs to basic ends or silica ends in the operating sequences just described. The initial conversion of a furnace to basic ends required about 20 days as compared with about 13 days for a complete silica rebuild. The minor repairs to basic ends require about 5 days and floor level rebuilds of either silica or basic ends require about 7 days. Main roof replacements requiring about 3 days are assumed to occur about every 150 heats.

As the table shows, the initial deficit of time required for installation of basic ends is more than made up in 6 main roof campaigns and from that point forward increasing time savings occur. Credit is claimed for this time saving at the rate of $50 per hour as being the normal furnace overhead charge. The furnace itself pays this charge when operating so that this time saving represents a definite dollar saving. No credit is claimed on the additional profit obtained on the increased tonnage of product, although this also is an appreciable item.

Table V shows the amount of slag collected from the slag pockets of a typical basic end furnace. Credit to the basic ends at a rate of $3.00 per ton is claimed for this slag on the basis that $3.00 per ton is a conservative estimate of ore cost.

Table VI shows the accumulated costs and credits for the basic end operation as compared with silica ends. The break-even point for this furnace occurs at about six main roof campaigns or 900 heats. In this length of time the basic ends have paid off their initial deficit of $40,000. Assuming a yearly production of 600 heats, this represents about a year and a half required to regain the investment. At the end of 12 main roof campaigns, or 1800 heats, the basic ends show a net credit of $50,000 over silica ends, or a net saving of $0.15 per ton of steel produced. At this same time, neglecting credits for time saving and slag recovery, the basic ends show a saving in repair cost of $26,000, or $0.08 per ton of steel produced. This figure has been verified in practice at the American Rolling Mill Company, where the total repair costs of a basic end furnace

TABLE III — Approximate Comparative End Costs for a Furnace with Basic Ends and Silica Ends

Items	Costs					
	Cost of converting silica ends to basic ends	Cost of complete replacement of basic ends after original installation	Cost of floor level repair to basic ends normally occurring at about 900 heat intervals	Cost of small repairs to basic ends normally occurring between floor level rebuilds	Cost of a complete replacement of silica ends normally occurring about every 900 heats	Cost of floor level repairs to silica ends normally occurring about every 300 heats
Tear down cost	$ 8,000	$ 5,000	$ 2,000	$ 1,000	$ 8,000	$ 4,000
Engineering charges including suspended brick, supporting castings, supervision, etc.	25,000	10,000	3,000	2,000	.....	.....
Changes to furnace steel work	10,000	.....	.....	.....	.....	.....
Unsuspended brick	20,000	20,000	13,000	8,000	15,000	10,000
Construction labor	10,000	10,000	7,000	4,000	10,000	6,000
Totals	$73,000	$45,000	$25,000	$15,000	$33,000	$20,000

TABLE IV — Credit Claimed for Time Saving in Rebuilding Basic Ends vs. Silica Ends

Number of main roof campaigns	Number of heats on ends	Repair days		Cumulative repair days		Time saving from use of basic ends	Dollar credit for time saving (furnace overhead at $50 per hour)
		Basic ends	Silica ends	Basic ends	Silica ends		
0	0	20	13	20	13	..	.....
1	150	3	3	23	16	..	.....
2	300	3	7	26	23	..	.....
3	450	5	3	31	26	..	.....
4	600	3	7	34	33	..	.....
5	750	3	3	37	36	..	.....
6	900	7	13	44	49	5	$ 6,000
7	1050	3	3	47	52	5	6,000
8	1200	3	7	50	59	9	10,800
9	1350	5	3	55	62	7	8,400
10	1500	3	7	58	69	11	13,200
11	1650	3	3	61	72	11	13,200
12	1800	7	13	68	85	17	20,400
etc.							

were $0.90 per ton over a period of 1922 heats, during which 347,000 tons were produced, as compared with a figure of $1.00 per ton for silica end furnaces.

The foregoing tables and figures carry a basic ended furnace through an operation of 1800 heats, or almost the total length of campaign to date of the oldest existing basic ends. At the end of this period, savings are still increasing. The ultimate savings that can be obtained from basic ends in this case cannot be determined definitely, but it can be shown that, neglecting non-repetitive installation charges, and assuming an ultimate life of the basic end structure of 3600 heats, the savings will approach $0.25 per ton.

TABLE V

CREDIT FOR VALUE OF SLAG DEPOSIT IN SLAG POCKETS

Number of main roof campaigns	Number of heats on ends	Amount of slag deposit in tons	Cumulative slag deposit in tons	Credit for slag at $3 per ton
0	0	0	0	0
1	150	100	100	$300
2	300	100	200	600
3	450	100	300	900
4	600	100	400	1200
5	750	100	500	1500
6	900	100	600	1800
7	1050	100	700	2100
8	1200	100	800	2400
9	1350	100	900	2700
10	1500	100	1000	3000
11	1650	100	1100	3300
12	1800	100	1200	3600

This figure appears to be a reasonable estimate of ultimate savings for the assumed case. On some other furnace of longer roof life and lower silica end costs, the savings per ton would be less. On the basis of present available data, it appears that the ultimate savings which can be obtained from the use of basic ends will vary between $0.10 and $0.25 per ton and that the yearly percentage return on the investment for installation of basic ends will vary between 40 and 70 per cent. while these figures cannot be predicted exactly for any particular open hearth shop or operation, it is safe to state that basic ends will prove economical and advantageous over silica ends under almost any operation conditions.

THE HISTORY OF THE ALL-BASIC FURNACE

As stated earlier in this paper, the all-basic furnace is obtained by adding a basic main roof to a furnace equipped with basic ends, front walls, back walls, etc.

The development of a successful basic main roof for

TABLE VI — Comparative Repair Costs and Credits — Basic Ends vs Silica Ends

			Silica ends				Basic ends			
No. of main roof camp.	No. of heats on ends	Tonnage produced cumulative	Cost of individual repairs to ends	Cumulative costs of end repairs	Cost of individual repairs to ends	Cumulative costs of end repairs	Credits to basic ends for time saving and slag credit (see Tables IV and V)	Net cumulative costs of end repairs after credits	Net cost or saving in dollars basic ends vs silica ends	Net cost or saving per ton basic ends vs silica ends
0	0	0	$33,000	$33,000	$73,000	$73,000	0	$73,000	—$40,000	.....
1	150	27,000	.....	33,000	.....	73,000	$300	72,700	—39,700	—$1.47
2	300	54,000	20,000	53,000	.....	73,000	600	72,400	—19,400	—0.36
3	450	81,000	.....	53,000	15,000	88,000	900	87,100	—34,100	—0.42
4	600	108,000	20,000	73,000	.....	88,000	1,200	86,800	—13,800	—0.13
5	750	135,000	.....	.....	.....	88,000	1,500	86,500	—13,500	—0.10
6	900	162,000	33,000	106,000	25,000	113,000	7,800	105,200	+800	+0.005
7	1050	189,000	.....	106,000	.....	113,000	8,100	104,900	+1,100	+0.006
8	1200	216,000	20,000	126,000	.....	113,000	13,200	99,800	+36,200	+0.17
9	1350	243,000	.....	126,000	15,000	128,000	11,100	116,900	+9,100	+0.04
10	1500	270,000	20,000	146,000	.....	128,000	16,200	111,900	+34,200	+0.13
11	1650	297,000	.....	146,000	.....	128,000	16,500	111,500	+34,500	+0.12
12	1800	334,000	33,000	179,000	25,000	153,000	24,000	129,000	+50,000	+0.15

Figure 7 — After 253 heats, the uptakes looked like this.

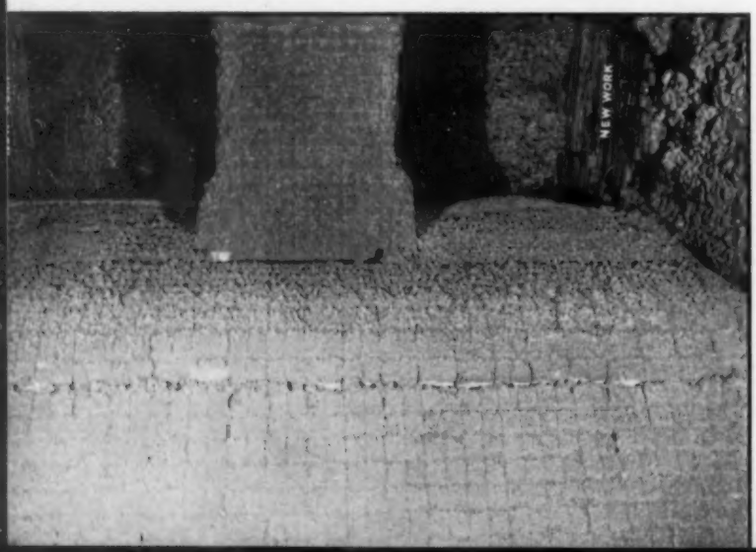
open hearths has been discussed and studied for many years. Early trials include the use of basic shoulders in sprung silica roofs and some completely sprung all-basic roofs. These tests were unsuccessful and it finally became apparent that suspension was necessary for the use of basic brick in large roof sections.

Suspended basic roofs were used successfully on copper reverberatory furnaces during the early 1930's. The construction employed three elements: a basic refractory brick, a means for support, and oxidizable metallic spacers in the brickwork joints.

The first attempt to adapt this construction to open hearth furnaces was made at the Bethlehem Steel Company about 1942. First, panel tests were made and, eventually, a complete main roof, knuckle to knuckle, was installed. These tests were not successful for several reasons, chiefly structural defects, and the frequency of shutdowns to other furnace sections, all of which caused accelerated wear of the basic roof. Since that time several main roof installations of similar design were made at the Ford Motor Company in Dearborn, Michigan. These tests have also been discontinued for similar reasons.

Almost coincident with the conclusion of the Johnstown tests, the first tests of basic ends were made at the

Figure 8 — After 501 heats, the unsuspended sections above the floor level required some patching.



Steel Company of Canada. These tests culminated in the trial of an all-basic furnace at this plant starting in February 1945. A new type of roof suspension was used and better results were obtained. The first roof was operated for 323 heats with one substantial patch after 221 heats. The second roof operated for 381 heats without any appreciable patching. Further design changes were indicated by these roofs and were incorporated in the third basic main roof. This roof ran for 347 heats without much patching and was removed when another part of the furnace failed. This roof would probably have run for over 400 heats. The fourth main roof is still on the furnace. It incorporated still further design changes and improvements. It has now operated for over 330 heats and more than one-third of the usable thickness of brick in the roof is intact. It seems likely that this roof will run for about 500 heats with little or no hot patching. When this roof has completed its campaign another basic main roof installation is planned.

The second currently operating all-basic furnace is

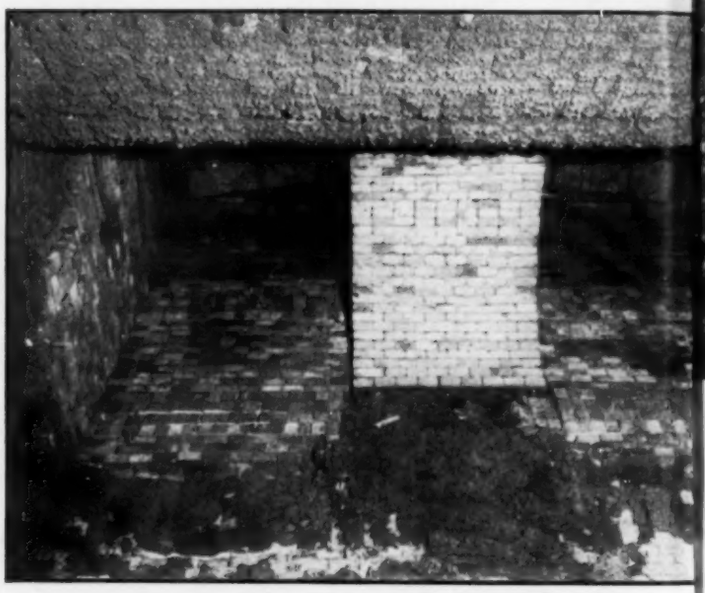


Figure 9 — Major end repairs were required at the end of 832 heats.

located at the South works of the Carnegie-Illinois Steel Corporation in Chicago, Illinois. This furnace was built as a part of an experimental project after long consideration of all the work done on this continent and of the data obtained on European furnaces following the war. The suspended furnace construction is almost identical in design to that at the Steel Company of Canada.

This furnace was built during May, 1947. It has now operated for over 300 heats. Some patches to the roof and end walls were required recently. The reason for shutting down the furnace for patching was chiefly the excessive wear of the endwalls although some of the test brick in the roof had become very thin and in these spots the roof was buckling out of shape.

The furnace has been operated on various practices, at varying fuel input rates and with and without oxygen additions for combustion purposes. It is thought that the extremely high fuel input rates and the correspondingly large volumes of exhaust gases at high tempera-

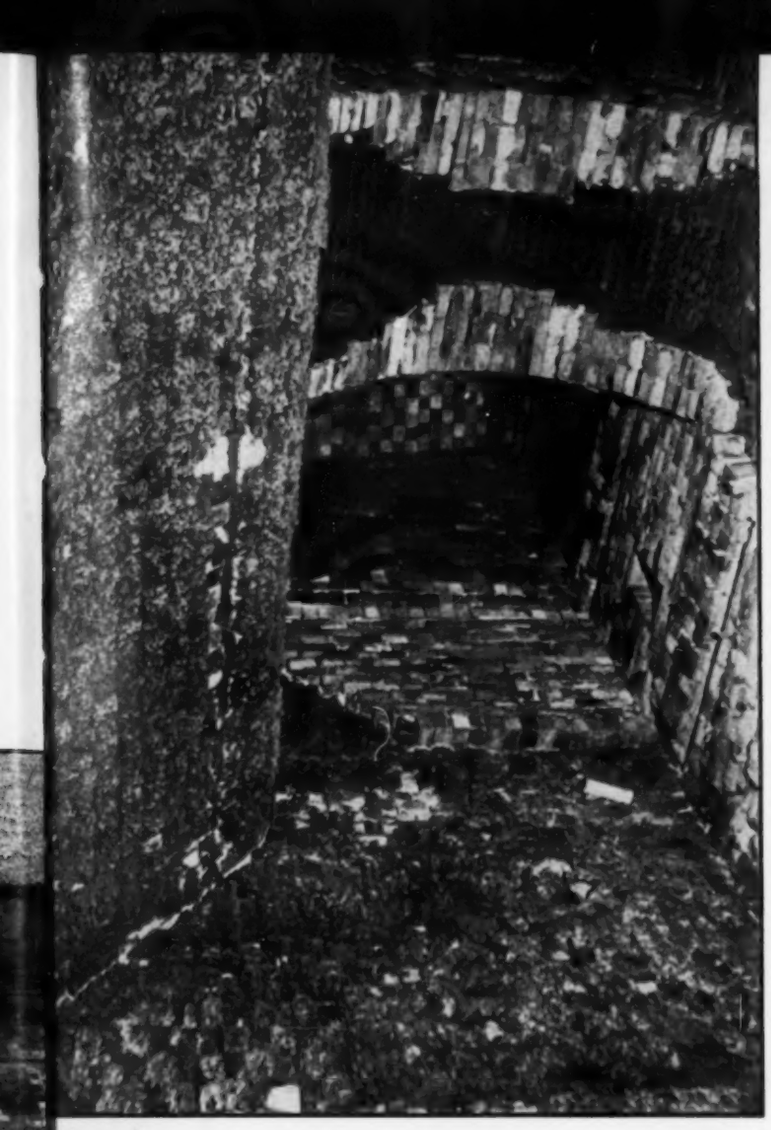


Figure 10 — At 1466 heats, floor level repairs were made to the ends.

tures are responsible for the unusually rapid wear of the endwalls, and that this can best be remedied by enlarging the furnace uptakes further.

A new basic main roof is to be installed at the conclusion of the present campaign and the experimental operating procedures are to continue.

STRUCTURAL DESIGN OF BASIC MAIN ROOFS

The first suspended basic open hearth roofs were constructed using a series of longitudinal pipes in the steel superstructure. The brick were suspended from castings attached to the longitudinal pipes. The bricks hung vertically and the arched contour of the roof was achieved by adjusting the vertical position of the pipes in the superstructure. This arrangement produced large corbels between the adjoining brick. When the roof was heated, the brick failed at the corbels and roof life was unsatisfactory.

In order to overcome this difficulty, the design was modified so that key shaped brick were hung from one edge and were canted toward the true arch position. This was done on the first two roofs at the Steel Company of Canada. It helped the condition but did not eliminate it completely. As a further improvement, the longitudinal suspending pipes were dispensed with and transverse structural members concentric with the desired roof curvature were built into the superstructure of the furnace. From these transverse members, radial, key shaped brick were hung forming a true arch but with the major portion of the weight carried by the steel superstructure instead of by the skews. This presented a smooth brick inner surface to the furnace and materially improved the life of the brick. Figure 16 shows such a roof and Figure 17 shows the suspending steel work.

A second gradual change in roof design has occurred in the allowance made for expansion. The early roofs were constructed with liberal expansion allowances. In many cases, more than the theoretical thermal expansion requirement was allowed. Tests showed definitely that smaller expansion allowances were beneficial.

This expansion allowance was gradually decreased until at present slightly less than the theoretical thermal expansion is left. To accommodate the remaining thermal expansion and any possible growth of the roof, the back skewback channel is detached from the buckstay and is moved into the furnace several inches. It is suspended from above and is held in position horizontally by springs which can be adjusted so that they deform at pressures below that needed to spring the roof. By this means the roof when hot is kept tight, but does not become sprung. When the furnace is shut down, the springs are tightened, thus moving the skew channel toward the center of the furnace and keeping all the joints in the roof tight at all times.

These changes in design have contributed very materially to the present success of the basic main roof.

BASIC MAIN ROOF BRICK

Many different bricks have been used, ranging from almost straight chrome to straight magnesite, manufactured by both burned and unburned processes. The relative merits of the different bricks were not exhibited in the roofs built according to the early designs, because the design itself speeded the failure of all. However, in the radially suspended roof, decidedly better results from one type of brick have been obtained. This brick

Figure 11 — At 1813 heats, it was finally necessary to replace an appreciable section of the basic brickwork below the charging floor level.

is an unburned or chemically bonded, steel plated, chrome-magnesite brick, especially developed for basic roofs of open hearth furnaces. This brick in service tests has shown lower costs, decidedly longer life, has been easier to construct, has less heat loss through it, and protects supporting steel work and castings better than burned brick.

The reasons that the brick have demonstrated these advantages are several. Chief among these are the inherent advantages of unburned or chemically-bonded brick. They are uniform in size and true to shape. They have lower thermal conductivity than comparable burned products and at mean temperatures over 1000 F, they have lower thermal conductivity than silica. They are of higher density and are less permeable to gases than burned brick. Because they are not fired, they can be marketed at lower prices than burned products. All of these things contribute to the success of the brick. The uniformity of size and shape contribute materially to the ease of construction. The lower thermal conductivity not only saves fuel through smaller heat losses, but also tends to protect the supporting steelwork which is exposed to the prevailing temperatures at the roof cold face. This is of considerable importance, because casting replacement costs can be an appreciable item in rebuilding. The greater density presents more refractory for wear and inhibits the penetration of fluxing dusts and vapors into the brick. All of these factors, with the lower initial cost and the longer life obtained, contribute to the lower costs of basic main roofs.

Two other features of this brick which also contribute to its success are the iron clip hanger socket and a clad steel jacket.

The socket, as stated before, presents the utmost thickness of refractory for use and also places the supporting casting at a position where it is exposed to the atmosphere and remains relatively cool. This both adds to the life of the brick and tends to decrease casting replacement costs.

The jacket applied to chrome-magnesite brick is an integral part of the brick. The brick is actually formed within the jacket, which extends around all four sides of the brick. This aids construction in that all the brick are identical, the steel jackets cannot come off, and there are no loose plates to be inserted in the joints. The integral jacket protects the enclosed brick so that breakage or damage during shipment is less with such brick than with burned brick. Tests have shown that the use of steel jacketed brick throughout the roof gives better results than a combination of clad steel brick laid alternately with unplated brick. The presence of additional metal in the joints is not the cause of the better results since the use of a single plate of greater thickness does not give the same result. The reason that the complete clad steel construction gives better results is that in each and every brick there is intimate contact between the brick material and the metal plate, strengthening the brick and insuring the desired reactions between the brick and plate materials. In addition, each joint is a metal to metal contact which in service welds together to form a firm and mechanically stable structure.

Figure 13 — Uptake wall of No. 7 furnace at the American Rolling Mill Company.

Figure 12 — The second all-basic furnace is the No. 7 furnace of the American Rolling Mill Company. View shows fantail nose and fantail roof.

ALL-BASIC FURNACE ADVANTAGES

The chief advantages of the all-basic open hearth furnace are increased furnace production and the possibility of lower operating costs.

The increased furnace production has been clearly demonstrated at the Steel Company of Canada. The increase results primarily from faster melting rates which can be achieved by virtue of the higher temperatures made possible by the all-basic furnace. In addition, there are fewer hot repairs, and rebuilds can be made

Figure 14 — Original brick in chill wall after 1600 heats on Armco No. 7 furnace.

faster, thus affording more operating time and a resulting production increase.

The overall production increase obtained at the Steel Company of Canada during the first all-basic furnace runs was 12.5 per cent. More recent dates indicate a production increase of slightly more than 14 per cent. The data on the South works furnace is complicated by the various operating techniques employed, but it appears that a sizeable production increase can be obtained from the all-basic furnace without oxygen additions or other similar practices.

The economy of the all-basic furnace is largely dependent upon the length of run of the basic main roof. The initial cost of an all-basic furnace installation, including the basic ends, is about $60,000 more than the cost of a complete silica rebuild. The replacement cost, however, would be only about $30,000 to $35,000 more than a complete silica rebuild. The roof installation cost alone is about $25,000. Subsequent roof replacements cost only about $15,000 as compared with about $5,000 for silica roofs.

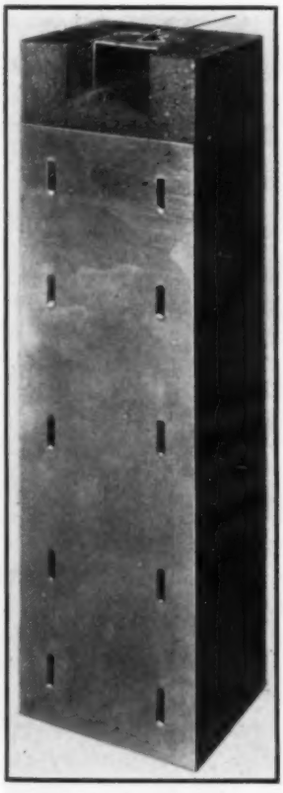


Figure 15 — This metal-clad brick is chemically bonded with a metal socket for use in supported walls and suspended roofs.

Figure 16 — Inner surface of a radially suspended basic main roof on No. 16 furnace at the Steel Company of Canada.

The increased production resulting from the all-basic furnace tends to offset these higher initial costs. Fuel costs per ton are generally decreased and overhead charges per ton are very markedly decreased. In addition, sizeable increased profits result from the sale of the increased tonnage produced.

On the basis of actual costs at the Steel Company of Canada, it has been shown that the total costs of the all-basic furnace are equal with those of a silica furnace at about 300 heats, if allowance is made for decreased overhead charges. It has been calculated further that the furnace costs will be even, neglecting the overhead credit for production realized from increased operating rates at about 500 heats.

The roof now in service at the Steel Company of Canada will probably run for about 500 heats. It has now produced over 300 heats and can be considered to have paid for itself.

These figures are probably a reasonable estimate of what can be expected from an all-basic furnace at the present time. Some problems, such as long charging times required for light scrap and the relatively short life of furnace front walls, tend to hinder the operation of all-basic furnaces at optimum rates at the present time. Work is being done on these things and further improvement of results from all-basic furnaces can be expected as solutions for these problems are obtained. The all-basic furnace is still an experimental project but it should soon become an open hearth tool which is recognized as generally as basic ends are now recognized.

CONCLUSION

The success of basic ends as an economical open hearth tool has been proved. Savings in the order of from $0.10 to $0.25 per ton of steel produced can be achieved by their use, and in addition, many desirable

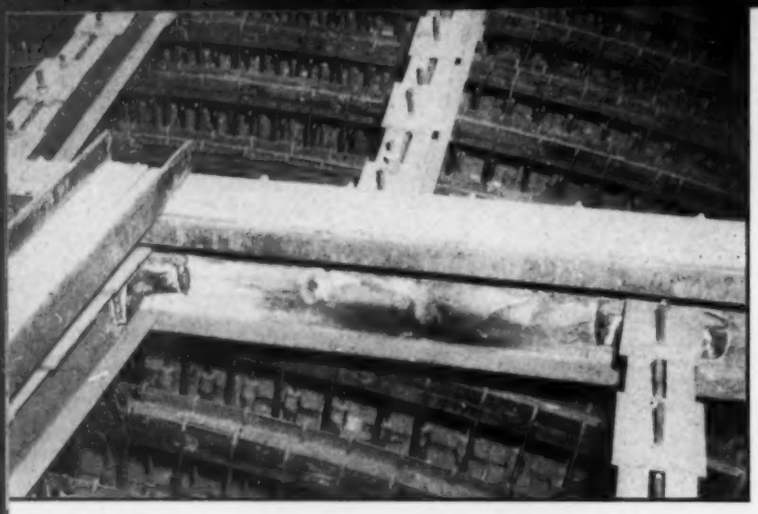


Figure 17 — Radial suspension of basic main roof of furnace shown in Figure 16.

labor saving and improved operating practices are made possible.

The results obtained thus far on the all-basic furnace are extremely promising and the goal of increased production at decreased costs by this means is within our grasp right now. Many problems which affect the overall application of all-basic furnaces still exist and at the present time it is not possible to recommend further trials of all-basic furnaces on other than an experimental basis, but the eventual complete success of the all-basic furnace in the near future is virtually assured.

DISCUSSION

PRESENTED BY

BURT BARNS, Ford Motor Company, Dearborn, Michigan

MERVIN FAY, General Refractories Company, Philadelphia, Pennsylvania

A. E. REINHARD, Superintendent, Steel Production, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

G. H. YOXALL, General Foreman, Masonry Department, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

RAY OVER, M. H. Detrick Company, 111 West Washington Street, Chicago, Illinois

P. C. DODDS, Ford Motor Company, River Rouge, Michigan

H. F. LESSO, Open Hearth Control Metallurgist, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan

P. E. HAGLUND, Melting Superintendent, Ford Motor Company, Dearborn, Michigan

Burt Barns: Do you have any idea how much air filtration there is from the all-basic furnace?

Mervin Fay: On an all-basic furnace on which measurements were taken the oxygen content of the exhaust gases was about 1 per cent as compared with normal oxygen content of about 2 per cent on silica furnaces.

Burt Barns: We have one at the present time with basic ends, and for the same amount of fuel, stationary furnace, same type, it runs approximately 2 to 3000 cubic foot of air less on that furnace than we do on the silica.

Mervin Fay: Normally, the plates on the basic brick will oxidize and swell yielding a very tight wall. It is liable to be less open than silica where variations in brick size cause openings.

Burt Barns: When you build the furnace though you allow for some, do you not?

Mervin Fay: The expansion joint used was described in the paper. A corrugated sheet is included in each joint. The back two corrugations are filled with compressible insulating material and the hot face of the joint is pointed with chrome ore.

Burt Barns: In other words, you seal those?

Mervin Fay: The expansion joints are relatively air tight.

A. E. Reinhard: The basic furnace is in the experimental stage, in fact, I would say it is a little past the experimental stage. Many things have been shown that greatly favor the basic construction also are points that are against it. I think the basic furnace will find its place in the steel industry, but before we do see it used universally, there will be improved construction and possibly better brick. Since 1945 silica brick has increased approximately 36 per cent in price, while basic brick has increased 11 per cent. In the case of silica brick, that means $17, while in basic brick it is $50 per 1000 - 9 in. equivalent. Naturally the basic furnace must pay its own way. The high cost, plus the scarcity of brick, makes many reluctant to experiment at this time.

G. H. Yoxall: Comparing the type of construction of basic roofs with the silica roofs from the figures that you quoted, you would have to get approximately four and a half times as many heats upon basic in order to make up for the time and cost in the initial building of that furnace. In one instance, putting the slope and top flat of the basic furnace, the approximate time of construction of a sprung basic, not a hanging, but a sprung basic, was 18 man hours of labor. A silica at the same section took approximately 2½ hours. Now, the overall picture of tonnage in cost would be as many times that over silica and a hung basic. Will the run of the furnace cover the overall and initial cost of changing to basic?

Mervin Fay: There will be an advantage in favor of suspended basic construction over a period of time. It is a matter of more than initial cost and construction time. Obviously you can build a sprung silica roof faster than a sprung or suspended basic roof.

G. H. Yoxall: It is also cheaper, because there is not the new steel in the sprung silica roof that there is in the sprung basic or hung basic.

Mervin Fay: That is right. However, on the suspended roofs we have found steel costs are largely non-

repetitive and the decreased repairs and longer life yield savings in time and money with basic construction.

Ray Over: In direct time or direct cost, as you mentioned, you have an item to start with that runs approximately three times the original cost of silica, and it takes you two or three times as long to install it, but a good part of that first installation consists of steel framework, truing up all of your supporting members so that they are exactly where you want them, and that is not repetitive as it only occurs once. After that, patching is done very conveniently and very quickly.

G. H. Yoxall: Does it stand the thermal shock when you have to shut down for minor patching? Our experience has been that we found the roof will buckle.

Ray Over: We are talking of two different types of roofs, for one thing, you are talking about a sprung roof with a swivel skewback.

G. H. Yoxall: One with a spring skewback.

Ray Over: Yes, a spring rotating skewback, and I am talking about one of our design where everything is hung. It is a simple matter to replace a small section in that roof because it will not fall in.

G. H. Yoxall: But the cost is even still greater by hanging a roof which involves structural steel.

Ray Over: Right, except a good many of the hangers are salvageable, and your top supporting members can be considered as a permanent rigid binding or binder.

G. H. Yoxall: Silica brick has a difference in degrees of probably 2000 in a 15 in. length, and half way in that brick you get a shock which automatically breaks it. Do you think the day will come when you will combine basic with silica?

Ray Over: Well, they have done that but it has not been too successful, as far as open hearth roofs are concerned.

G. H. Yoxall: The excessive expansion which happens in one 15 in. brick, is what is ruining our silica right now.

Ray Over: You are talking about one of the biggest troubles we have to overcome, which is thermal shock when the furnace goes down.

G. H. Yoxall: The thermal shock on basic brick, from the experience I have had, is much greater than thermal shock on silica.

Ray Over: That is right. There is a tendency toward peeling or spalling of the inner face, particularly when the iron oxide absorption has been high.

Mervin Fay: That is on burned brick; however, on unburned brick you will find that the loss from thermal shock is very low.

G. H. Yoxall: You speak of slag reaction, with the silica end of the furnace, on the roof, I mean the top flat and the slope and the basic side, you can still get the same results that you can get from basic ends and a basic roof, as regarding the slag deposit.

Mervin Fay: I think it has been noticed at other places that basic end wall panels, both in the end wall and on the side walls and possibly on the side of the burner arch, have yielded a very decided softening of the slag deposit.

G. H. Yoxall: The softening of the slag has been great, compared to the silica end and silica side walls, but it will not hurt enough as the deposit of basic in your walls will overcome the amount of silica you have in your roofs.

Mervin Fay: Yes, however, basic walls will wear faster with a silica roof.

G. H. Yoxall: I disagree with that. From experience, 13 in. basic side walls outlasted 22½ in. silica wall with a silica roof on top.

Mervin Fay: I expect that with a basic roof above the basic walls they would last even longer.

G. H. Yoxall: The thermal shock on your basic roof, of course, at least it has been our experience with the hanging roof, or even with a sprung roof, is such you cannot take any chances. If you go down for a minor repair you have to put a protective scaffold under that roof.

Mervin Fay: I have had no experience with sprung basic roofs for open hearths.

G. H. Yoxall: That is the only one I had experience with.

Mervin Fay: We have had about five shutdowns of suspended basic roofs without any spalling of the hot face of the basic roof. This was true in both the main roof, and the port roofs. We have had innumerable shutdowns on the port ends without any appreciable spalling.

G. H. Yoxall: You speak of 500 heats on your basic hanging roof?

Mervin Fay: Yes.

G. H. Yoxall: Would that be enough to compensate the initial cost compared with silica?

Mervin Fay: Yes, since there is an increase in furnace production of roughly 14 per cent.

P. C. Dodds: We have been talking basic refractories the last few days at the Ford Motor Company and we are now putting basic bulkheads in our silica furnaces. They looked pretty good up until now. We are using different types of plates between each course of brick that are not metal encased, and are finding that some are creeping in, which we expected and have prepared for by putting some large plates every five courses which all the refractories companies recommend. I delayed for three days the welding of these plates, waiting for the full expansion of the silica work against the bulkhead to take place. After the third day the bulkhead started to move, and we had to get busy and weld the big plates down. In discussing this, I understand that some of these bulkheads that are being put into furnaces are creeping out. Do you know of this, and is there any explanation why bulkheads today are creeping out, where in the past years they have been creeping in?

Mervin Fay: I have seen such walls move both in and out in one bulkhead. The movement is caused by horizontal expansion of the wall and can result in bowing in either direction. The most successful solution to this problem is to use tie plates in the manner you described, and fasten them to the external furnace steelwork in such a way that they can move vertically to allow for silica expansion, but cannot move horizontally.

P. C. Dodds: Have you ever experienced the large plate being incorporated within the silica brickwork of the uptake walls?

Mervin Fay: You mean with a basic facing on the inside of a silica wall?

P. C. Dodds: That is right, the large plate where you are going to tie the bulkhead.

Mervin Fay: That has been done a couple of times. I have not had any personal experience with it.

P. C. Dodds: I did some experimenting on two furnaces in Mexico, and we had a lot of success, both 9 in. basic wall and 13 in. metal encased wall. The tie plate extended into the uptake wall about 4½ in.

H. F. Lesso: The questions so far have had to do with furnace production. I would like to ask Mr. Fay what the standard methods are in the selection and preparation of a suitable material in the manufacture of a good basic brick. What are the maximum and minimum requirements, as to concentration and variation in the primary component of a raw material and the limits of the secondary component?

Mervin Fay: The two principal materials used in basic refractories are chrome ore and magnesite. The chrome ore is the major constituent in basic open hearth roof brick. It should be hard and lumpy ore. We prefer a Cr_2O_3 content of about 35 per cent and an alumina content close to 30 per cent, with suitable magnesia and iron oxide. The silica content should be less than 5 per cent. The magnesite constituent of the brick can be seawater magnesite or natural grains of high MgO content, and low silica and lime content. They should be thoroughly calcined and sintered.

H. F. Lesso: Have you found in the performance of these various basic bricks that any relationship is indicated between such performance and the original iron content of the mineral in the raw material.

Mervin Fay: No. Over a period of years we have used various chrome ores from Cuba, the Philippines, Greece, etc., which vary somewhat in this particular. We have not found much difference in their performance. However, all the refractory grade chrome ores used are of relatively low iron content because of manufacturing difficulties experienced with high iron ores.

Member: The majority of the chrome ores used are the range of 26 to 35 per cent Cr_2O_3, and the African is up around the range of 43 to 48 per cent, but it has not been used largely in brick work. It has been more in specialties.

P. E. Haglund: Mr. Fay mentioned that the basic refractory conductivity was good compared with silica. How about your metal-clad brick with your two thicknesses of metal at the joint? How does your overall Btu loss through your roof compare with the straight silica?

Mervin Fay: Experimental work in our laboratory has shown the heat loss through a suspended basic roof of our unburned metal-clad brick to be about the same as that through a silica roof of the same thickness. The thermal conductivity of burned basic refractories is generally higher than silica brick, but unburned basic brick show lower thermal conductivity than silica at high temperatures. The plating of the brick does not appear to have much bearing on heat loss. The plate becomes oxidized rapidly in service and only the edge of the plate is exposed on the cold face of the roof. Fuel figures on the all-basic furnaces have not varied widely from those on comparable silica furnaces, so it seems likely that heat losses are about equal.

Don't Forget the Dates!

September 28, 29, 30 and October 1, 1948

IRON AND STEEL EXPOSITION

AND

AISE ANNUAL CONVENTION

Cleveland Public Auditorium

CLEVELAND, OHIO

IMPROVED METHOD FOR MOUNTING BEARINGS AND COUPLINGS

. . . . the use of adequate interference in shrink fits is limited by problems in removal . . . . the oil injection method eliminates some of these troubles . . . .

By A. S. MURRAY
Assistant Chief Engineer
SKF Industries, Inc.
Philadelphia, Pennsylvania

▲AN oil injection method has been developed to facilitate the application of roller bearings to marine shafts that must be coupled by rigid couplings. This method has been found subsequently to be capable of varied application and to be of more general interest. It may be advantageously used to mount and dismount many types of interference joints used in heavy industry, and is of additional interest in the dismounting of large roller bearings.

The creep of loose-fit mounted roll neck bearings, and the resultant wear and scoring of roll necks is well known to the engineering and maintenance departments of steel companies operating continuous hot and cold strip mills. The undesirable features of the loose fit type of mounting have been accepted because the frequency of roll changes, and the previous difficulty of dismounting large roller bearings when mounted with an adequate interference fit, left no alternative; so it is felt that this new method may be of interest to many who have come in contact with this problem. The oil injection method is based on the fact that friction between contact surfaces of a pressure joint during fitting and dismantling can be almost entirely eliminated with the injection of oil under pressures of 5,000 to 25,000 psi, depending on the specific pieces and their respective functions.

Before considering the manner in which this method is used in practical applications, it would be well to review its principle. When a ring is shrunk on a cylindrical shaft so that an interference fit results, the contact pressure between the two parts is not constant along the shaft. The shaded areas in Figure 1 indicate schematically how the pressure varies from end to end of the ring. The edge loading indicated at each end of the ring and at the oil groove in the center is caused by the fact that the shaft material opposite the edge, as well as that adjacent but beyond, must be compressed by the edge of the ring. A radially drilled hole connected to a peripheral groove in the ring bore, permits oil under pressure to be introduced between the contacting surfaces. Figure 1A shows pressure distribution along the entire length of contact before the introduction of oil under pressure. Figure 1B shows the condition after some oil has been introduced and the oil pressure has reached the same value as the average specific pressure prevailing in the joint adjacent to the oil groove. As the pressure is increased by the introduction of more oil, the contacting surfaces are forced apart as in Figure 1C and the oil commences to flow into the more distant parts of the joint. In the final condition, as shown in Figure 1D, a thin oil film separates the contact surfaces completely with the exception of a narrow zone at each end of the ring. Here the contact pressure is greater than at any other part of the joint, due to the influence of the shaft material beyond the ends of the ring. This phenomenon, which many know and refer to as "end effect" is the condition that allows the oil film method to work. The end zones act as oil locks, which retain oil until the pressure rises sufficiently to further expand the ring and an oil film completely separates all parts and prevents any important metallic contact.

Experiments have shown that by the above described use of oil, friction between contact surfaces can be reduced to 1 to 2 per cent, and less, of that which would otherwise prevail. When the pressure is released the oil

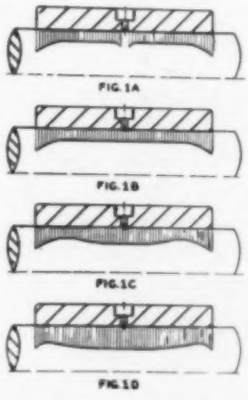


Figure 1 — The length of the lines in the shaded area are a measure of the contact pressure.

Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 25, 1947

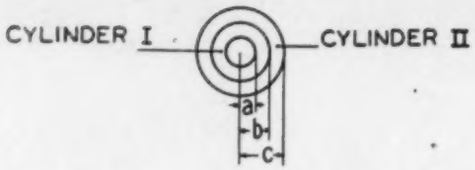


Figure 2 — This sketch has been set up to illustrate the nomenclature for the stress-interference formula.

escapes through the supply port and the original friction is restored. This new mounting technique applies, in the routine calculations for its employment, old and well-established formulae. The following discussion reviews the fundamentals, as well as indicates the possibilities of this system by specific example and application.

It is possible to calculate the contact pressure that exists between two parts in which the bore of the outside piece is smaller than the outside diameter of the inside piece. This pressure and the stresses produced by it are a function of the interference, which in turn is affected by the manner in which the two parts are assembled. The heating of the outer piece so as to shrink it on the inner causes no reduction in the amount of measured interference, such as occurs with assembly by cold pressing and the inevitable shearing off of metal.

After cooling, the resultant contact pressure is properly described as the shrink fit pressure. The magnitude of this pressure can be calculated according to a formula given in Timoshenko's Strength of Materials, Second Edition, Part II, Chapter V. Figure 2 shows two hollow cylinders that illustrate the general case, and the symbols used in the formula are described below:

a = Internal radius of cylinder I.
b = Nominal external radius of cylinder I.
b = Nominal internal radius of cylinder II.
c = External radius of cylinder II.
p = Contact pressure between cylinder I and II.
E = Modulus of elasticity (steel = 30,000,000 psi).
δ = Amount the external radius of cylinder I is bigger than the internal radius of cylinder II.

$$p = \frac{E\,\delta}{b}\,\frac{(b^2-a^2)\,(c^2-b^2)}{2b^2(c^2-a^2)}$$

In the case of a hub, or specifically the inner ring of a bearing being mounted on a solid shaft, a = O and the formula is greatly simplified:

$$p = \frac{E\,\delta}{2b}\left\{1-\left(\frac{b}{c}\right)^2\right\}$$

The ratio $\frac{\delta}{b}$ is dimensionless, and numerically equal to the interference per unit of shaft diameter (thousandths of inches per inch).

With this background it is interesting to consider one of the specific cases that we have carefully investigated in the laboratory. The mounting is shown in Figure 3.

The bearing is shrunk onto the arbor and there is an

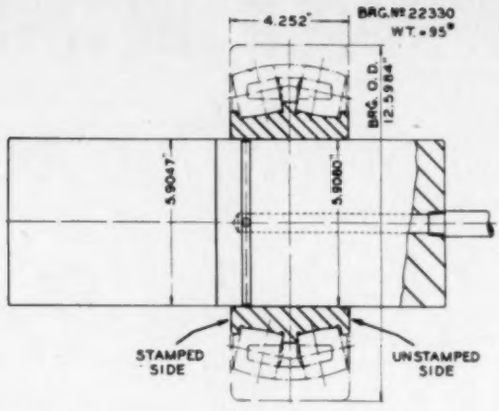


Figure 3 — Arrangement of cylindrical bore ring for dismounting by oil injection.

actual interference between bearing bore and shaft seat of 0.0028 in. With this interference, and the dimensions indicated on Figure 3, the contact pressure can be calculated according to the formula:

$$\text{Contact pressure} = \frac{E\,\delta}{2b}\left\{1-\left(\frac{b}{c}\right)^2\right\} =$$

$$\frac{\left(30\times10^6\right)\left(\frac{0.0028}{2}\right)}{2\left(\frac{5.91}{2}\right)}\left\{1-\left(\frac{\frac{5.91}{2}}{\frac{8.35}{2}}\right)\right\} = 3550 \text{ psi.}$$

When Figure 3 is actually connected for the introduction of high pressure oil, Figure 4, and an adequate pressure is built up, the separation of parts is usually so complete that the dead weight of the bearing itself will displace the bearing a distance greater than the width of the bearing and uncovers the oil port by at least an inch.

A study of Figure 3 will show that the oil port is much closer to one side of the straight bore bearing. This is an important detail and the off-center location of the port should be in the same direction as the motion when stripping a bearing from its seat. As noted in the preceding paragraph, the race in Figure 3 uncovers the oil outlet by about an inch, and then stops because of a rupture of the oil film that can no longer be maintained by the pump.

Usually the straight bore bearing will not come completely off its seat because an oil film cannot be sustained by too small an area regardless of the location of the port. Accordingly, the bearing hangs on the edge and we have used the press shown in Figure 4 to measure the force for final removal. It has varied between 5,000 and 12,000 pounds and is usually about 9,000. When the bearing is removed as in the past by pressing or pulling, the initial starting resistance varies between 50,000 and 60,000 pounds. It is obviously a great help to have to pull only a distance of ½ in. instead of 4 in. with an effort of only 16 per cent rather than 100 per

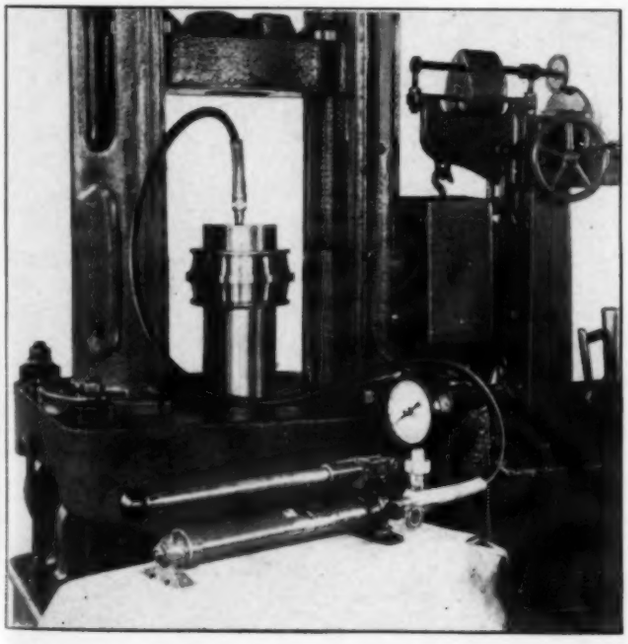
cent, and this is accomplished through the use of oil injection.

With further reference to the location of the oil port, it is already evident from the successful dismounting with an off-center outlet that the sealing by end effect, as discussed in connection with Figure 1, is an actuality. Outside diameter measurements of the two outer flanges and the one central guide flange with the oil port, both off and on center, give added corroboration to the reality of the higher pressures that occur at the edges as the result of this so-called end effect. Using the testing arrangement indicated in Figure 3 and pictured in Figure 4, the resultant measurements of the outside diameter expansion indicate very clearly the pressure drop at various axial locations and the usefulness of the end effect in helping to build up pressure in the bore from side to side before permitting escape past the edges. The case of extreme off-center location of the oil port in Figure 5 shows how the unstamped side flange expanded, but the end effect sealed this same side until the pressure developed to expand the center and the stamped side flanges. It was not until the oil had traveled through the bore for a distance of three inches, to establish a complete oil film between the bore and the bearing seat, that the edge $\frac{5}{16}$ in. away lifted. Figure 5 also shows the maximum oil film thickness at the port is only 0.001 in. thick as shown by maximum diametral ring expansion.

While this hydraulic method is of great help in the dismounting of bearings with cylindrical bores, it is most effective when used with parts that have mating tapers. Another laboratory model, Figure 6, was provided for demonstrating to skeptics that this principle will work with large pieces, as well as with the small ones usually used for convenience in testing. The tapered bore bearing is mounted directly on a seat with a 1:12 taper on diameter. A model, built in accordance with Figure 6, is pictured in Figure 7 with the bearing axis vertical and the small end of the taper at the top.

When oil at 2800 psi is supplied to only the plunger

Figure 4 — This test set-up was made to dismount cylindrical bore ring by oil injection.



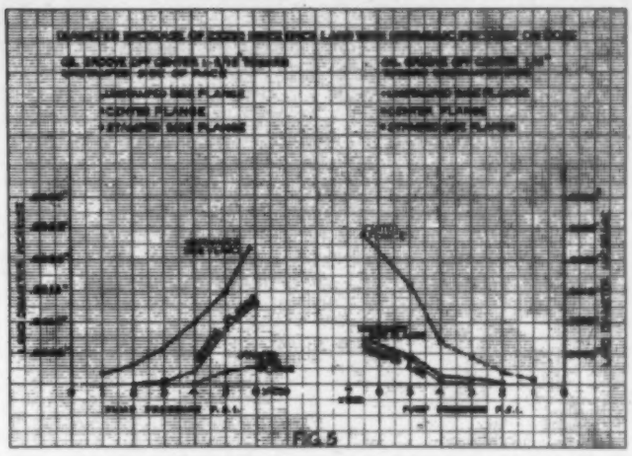


Figure 5 — This chart gives the increase in diameter for a particular bearing when oil is applied under pressure.

in Figure 7, the 44 sq in. working area develops an axial push of 123,000 lb and this force is sufficient to expand the ring only 0.0024 in. When, in addition, oil is introduced into the bore at 3300 psi, the outside diameter of the inner ring further expands to a total of 0.010 in. These figures indicate that the bearing is mounted with the equivalent of 0.0126 in. interference fit between bore and seat.

It must be remembered there is a component axial force from the hydraulic pressure when it is present between a tapered bore and its seat. This force is equal to the area of the axial projection of the seat times the average pressure over the oil film area. In Figure 6 the axial force is equal to 99,000 lb if we use an estimated average pressure of 3250 psi when the maximum gage pressure at the pump is as high as 3500 psi before the bearing is mounted.

The ring in Figure 6 has an "as mounted" interference of 0.0126 in. and we can reasonably assume a measured oil film thickness of 0.001 in. (see Figure 5). When calculating the contact pressure for a total interference of 0.0146 in. the theoretical value is 3360 psi.

The relatively irregularly shaped section of a bearing inner ring with a 1:12 tapered bore, requires the exer-

Figure 6 — Arrangement for dismounting tapered bore ring by oil injection.

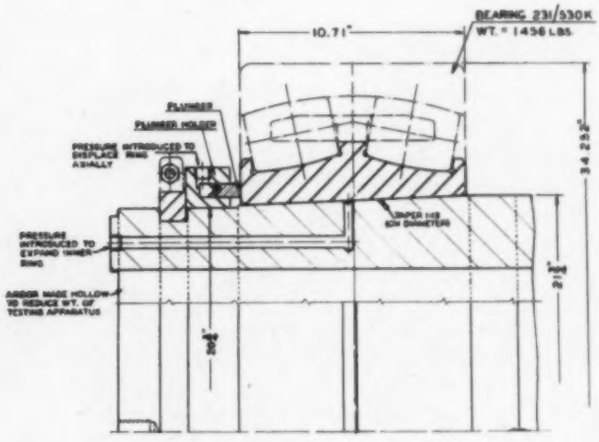


Figure 7 — This set-up for dismounting was made to demonstrate the applicability of the method to large tapered bore rings.

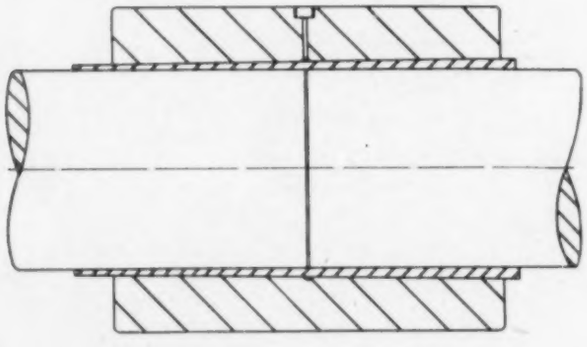
cising of some judgment to select dimensions of an equivalent rectangle. In spite of this slight handicap, we find consistency between observed and calculated axial displacing forces, with the former 120 to 130 per cent of the latter. In the specific case of Figure 7, the measured force of 123,000 lb is 124 per cent of the theoretical 99,000 lb.

When dismounting a tapered bore piece from its seat, pressure is applied to the bore only, and generally results in the piece being freed from the tapered seat so completely and uniformly that it becomes desirable to supply a safety stop to prevent injury to people and damage to equipment from possible over-travel, particularly when the axis is horizontal. The assembly, Figure 6, weighs 1400 lb and the energy liberated as a result of the sudden return of the inner ring to a free condition, after having been elastically strained, is enough to make the whole assembly jump about ½ in. into the air.

It will be of interest to some that the bearing in Figure 6 has the same bore as the backup roll neck bearings initially equipped on the 42 in. hot strip mill at McDonald.

At the beginning of this paper it was stated that this

Figure 8 — This rigid coupling depends on pressure only to transmit the torque between the shafts.



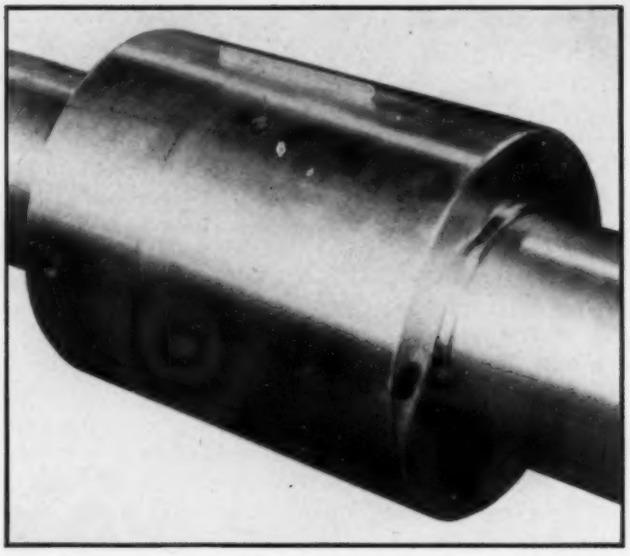
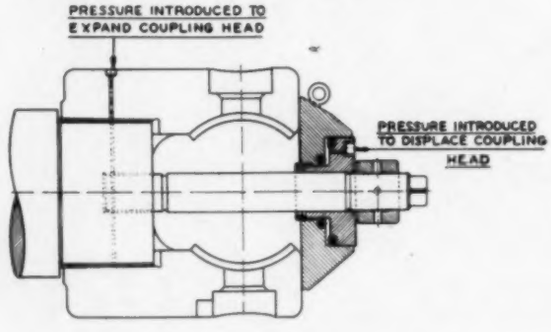


Figure 9 — Test assembly of coupling used in a marine application.

principle was developed to make more attractive the supporting of marine shafting by roller bearings. One of the principal attributes of plain bearings was that they permitted the use of couplings forged integral at the end of each section of shafting; a new rigid type coupling developed by our company overcomes the objections to the older removable types. During the early part of 1944 the first couplings were installed, and they have been followed into service by more than one hundred additional units. The shafts so coupled now range from 5½ to 18 in. in diameter. The troubles of the previous designs stemmed from the difficulties encountered in fitting, assembling, and maintaining the keys, keyways and drive fits. Preliminary testing by a very important federal department has been both encouraging and interesting to all concerned in the possibility of applying roller bearings to marine shafting, which has now become convenient because of this improved coupling. The coupling in Figure 8, depends on pressure only and unites two purely cylindrical shaft ends without the use of keys or any similar device. The clean lines of the coupling make any guard quite unnecessary. The couplings are so dimensioned that they can transmit torque up to the point where ordinary shafting passes through the yield point and takes a permanent set. The outer sleeve is made of high-carbon, high chrome-bearing steel, heat treated to develop desirable

Figure 10 — This coupling for a 2-high blooming mill was designed for removal by oil injection.



physical characteristics for this specific purpose, and, at the same time complying with Lloyd's specifications.

We can calculate torsional capacity of a coupling by multiplying the contact pressures times the area over which it is exerted, times the torque radius, times the coefficient of friction. It is quite easy to know when the proper interference has been obtained in the process of assembly. An outside micrometer is the only instrument necessary to determine when the outer sleeve has been expanded enough to obtain the desired contact pressure. The outer sleeve expands according to the formula:

$$\text{Increase in outside diameter} = \frac{2\delta b}{c}$$

If a coupling is manufactured in accordance with our specifications, a desirable interference between standard coupling sleeves in order to provide high torque capacity, is 0.003 per unit of shaft diameter.

Twenty-four couplings, Figure 9, have just been completed for use in six new ships. To couple the 7⅜ in. shafting, the outside diameters of the couplings will be expanded approximately 0.013 in. The twin screw ships have two couplings per shaft, and a 1200 hp diesel engine drives each lineshaft at 300 rpm when the ship is running at a top speed of 13½ knots. Our bearings have also been selected to support the lineshafts.

The steel industry has many places in which special adaptations can be made, as required for the individual application. Beginning in 1937 a number of 30 in. blooming mills for rolling high alloy steel were equipped with our bearings on the roll necks, and beginning two years ago some were modified to receive couplings mounted and dismounted by the hydraulic method. The application, Figure 10, has transmitted three and one-half million (3,500,000) inch pounds torque while measurements were being taken, and this corresponds to a torsional stress of 5200 psi at the roll neck coupling seat. Also indicated on Figure 10 is an hydraulic assembly arrangement to force the coupling head up the taper against the axial component that results from the hydraulic pressure expanding the coupling head, and reacting against the thin intermediate sleeve that is between the coupling head and the roll. Instead of a cold assembly, the coupling head could be heated and shrunk in position, and the hydraulic method used for dismounting purposes only.

In the relatively brief period during which we have been accumulating actual experience with this method of making and breaking heavy interference fits, we have tried many variations of the details discussed. For their particular use many of the variations not mentioned are equally important and successful. I have tried only to give a sense of proportion and create a feeling of confidence in the possibilities of this hydraulic method as a result of a review of factual data.

ECONOMIC CONSIDERATIONS FOR STACK LINING REPAIRS

By W. R. TROGNITZ, Carnegie-Illinois Steel Corporation

▲COMMON reasons for terminating a furnace campaign, occurring either singly or in combination, are: extreme deterioration of furnace performance, hearth breakouts, stack lining failures, and excessive copper losses. Particularly difficult are cases where there are no outward signs of lining troubles, but furnace performance shows all the reactions normally associated with a worn lining.

Ohio Works Furnace No. 2 was blown in after a complete relining during July 1940. In August 1941, the hearth wall failed and a new bottom was installed while the bosh and stack lining were supported at the elevation of the tuyere coolers. During this shutdown no repairs were made in the stack. Blown in again in September 1941 the furnace operated continuously until May 1945 when it was blown out for renewal of the stockline wearing plates. The remainder of the stack lining was almost entirely free of scabs and worn surprisingly uniformly from its original thickness of 42-48 inches to the thinnest section in which 24 inches of brickwork remained. Overall repairs to the furnace consisted of replacing 24 feet of brickwork above the mantle and renewal of the stockline wearing plates with four feet of brickwork below and the dome brick above. Total outage of the furnace was 31 days.

The furnace started its campaign with an average daily output slightly in excess of 1100 tons which gradually dropped to 950 tons after 1750 operating days. After repairs were made the average daily production resumed at 1020 tons and tapered off to approximately 960 tons. The coke consumption during the initial months was 1500 pounds per ton of iron and rose to over 1800 pounds. After lining repairs, the coke rate resumed at 1640 pounds and gradually climbed to 1750 pounds near the end of the campaign.

The significant feature is the gain of 17,500 tons of iron production during five fall operating months without additional coke requirements. If the lining repairs had not been made, the production of 17,500 tons of iron would have required an additional 16,200 tons of coke. This coke saving alone, during the five months period and at the prevailing price of coke delivered at Youngstown, more than paid for the overall cost of the repairs.

It can be concluded that, under certain conditions, it is economically sound to repair blast furnace linings after an initial operating period of 1600 days, or more. The restrictive conditions can perhaps best be summarized in the question: "Will the furnace run safely for another two or three years?" or expressed somewhat differently: "Will the unrepaired sections of the furnace support another run of two or three years?" If the answer to these questions is in the affirmative it appears advisable to proceed with lining repairs. In most instances the condition of the hearth very likely will be the critical factor in reaching a decision.

Condensation of paper presented before Eastern States Blast Furnace and Coke Oven Association, Pittsburgh, Pennsylvania, February, 6, 1948.

Economics of Britain's Steel Industry

. . . . this report on Great Britain's steel industry was prepared for a broadcast on the BBC . . . .

By ROBERT SHONE
Economic Director and Secretary
British Iron and Steel Federation

I. ECONOMIC STRUCTURE

▲ IT is difficult to discuss the economic structure of the British steel industry, since as an industry it forms only a part of the whole structure of British manufacturing industry which starts from the raw materials — iron ore, coal, and scrap — and proceeds right through to the making of mechanical and structural products, motor-cars, ships, industrial equipment, food containers and innumerable articles in daily use. It is often an arbitrary matter where the dividing line between the steel industry on the one hand and the engineering and metal fabricating industries on the other begins and ends.

It is often economically desirable to carry forward to a considerable degree the processing and manipulation of steel on the site of the steelworks. This enables the gases from the blast furnaces and coke ovens to be used for power and other purposes, provides for saving in carriage, and for the more accurate adjustment of the production of the right qualities of molten steel to give the qualities of tubes, bolts and nuts, sheets, tinplate, girders, etc., which are required.

On the other hand, it is also valuable to have the making of these steel products closely geared in with the finishing trades so that their special requirements can be met. The structure of the British steel industry, therefore, is necessarily highly complex and varied. There must on the one hand be flexibility in meeting a vast range of demands for all the shapes and sizes, and for qualities from the commoner standard types to the alloy and stainless steels required to meet the increasingly severe standards of modern engineering development. Yet, with all this variety, the maximum degree of large mass production must be achieved if the economies peculiar to large integrated plants are to be realized. This dilemma is one of the fundamental issues which has determined much of the present structure of the British industry and must largely condition its future lines of development.

Notwithstanding these complexities, the industry produced, immediately on the termination of the war, a plan for development over the next 5 to 7 years. This was based on the scrapping and re-building of about 40 per cent of the existing capacity of the industry in Britain, and expanding its capacity overall from about 14 million tons a year to 16 million tons. The total cost of the scheme was estimated at £170 million (about $680,000,000). This plan of development has already been started and the benefits will begin to be felt during the course of 1947 from some of the minor schemes which can be quickly completed. The major developments, however, must take some three or more years to complete.

Possibly the fundamental economic factors in any steel industry are those determining its location. In this respect, Great Britain has considerable natural advantages. It has the three main raw materials available — coal, iron ore and scrap — and it has big markets close to the centers of production, and a highly skilled labor force, the total numbers employed in the industry being about 300,000. Of these raw materials, scrap is relatively in more abundant supply than in any other steelmaking country, good quality coal is normally abundant, but iron ore available for working in large quantities in the United Kingdom is of relatively low iron content, containing only about 30 per cent iron. These home ore supplies are therefore supplemented by the importation of higher grade ores from Sweden, North Africa and other sources.

The fact that coal deposits in the United Kingdom exist in many areas and frequently close to the ports, has made the production of steel on high grade imported ores economical at coastal sites in relation to the production of steel on the cheaper but lower grade home ores which are situated mainly in the center of the country. As scrap arises in each of the industrial areas in Britain, it has been economical to develop production in many different parts of the country, generally speaking close to the engineering and other industries using steel. Thus, big centers of steel production have grown up in Scotland, on the North East Coast, in South Wales, in Sheffield, Birmingham, Lancashire and other areas. This dispersion of the industry as compared, for example, with the more concentrated production in America, has partly been responsible for the smaller size of plant in the United Kingdom, balanced by a carriage cost averaging considerably less than half the carriage in America from the steelworks to the consuming industries.

The problem of whether future expansion in Britain

should take place on imported ore in the coastal areas, or on home ore in the Midland area has required careful study. On balance it has been decided to undertake the main expansion on the home ore basis. This involves using more coal per ton of steel and a larger quantity of capital equipment to handle the bigger volume of lower grade raw materials. Nevertheless, the economies effected by the quarrying of ores alongside the steelworks are sufficiently great to make it desirable to develop primarily on this basis.

While the main expansion is, therefore, in the Midlands, a great deal of modernization and re-building on the coastal sites is also going forward, particularly because the exacting demands, for example, for high grade sheets for pressing into motor-car bodies, make it preferable to start the steelmaking process with richer imported ores.

The second fundamental consideration regarding steel economics is the size of unit. Here, the whole tendency in Britain is towards larger units. For instance, as part of the five-year plan it is proposed to build steelworks in South Wales capable of producing one million tons a year of continuously rolled strip for sheet and tinplate making. It has been found generally that for British conditions, the most economical units for steelmaking involve capacity of between 500,000 and 1,000,000 tons a year at any one plant. To erect larger units than this involves very little if any further economy and if they were adopted, would involve a much greater concentration of production in one particular part of the country and would so lead to greater carriage charges in distributing the finished product to the other industrial areas. It is proposed to concentrate the primary production of semi-finished steel for the lighter products in five steelworks each having a continuous billet mill turning out somewhat over 500,000 tons of billets a year at each plant. This again permits the distribution of production throughout the country with three mills in different parts of the Midland area, one in Scotland and one on the North East Coast.

The developments of the industry along these broad lines, with their associated blast furnace and coke oven plants, are so planned that it is anticipated that the increase in production by about 2 million tons a year can be achieved with practically no overall increase in total coal consumption by the industry, or in the total labor requirements.

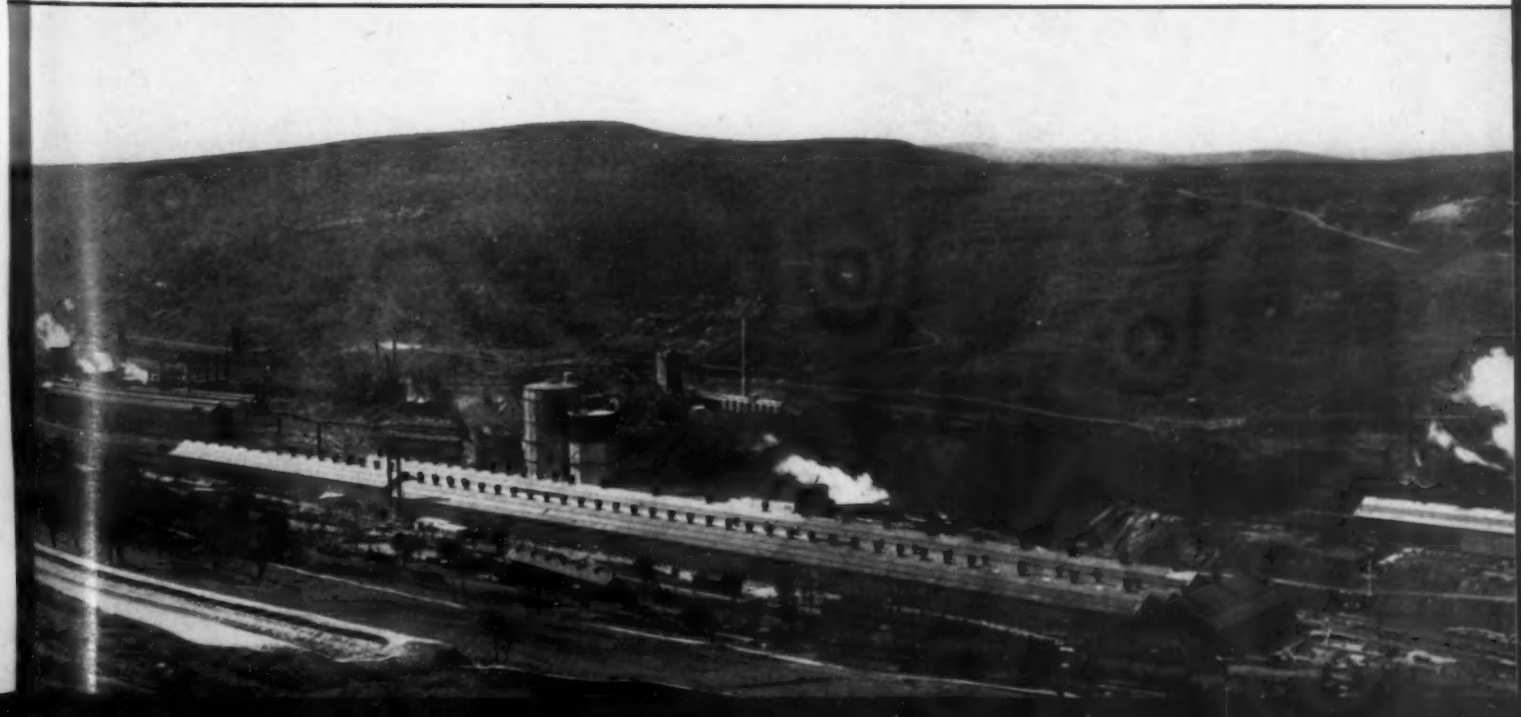
On the export side, the United Kingdom industry before the war was exporting 2½ to 3 million tons of steel a year, or over 20 per cent of its production. This compares with American exports at about 10 per cent of production. In view of the increased importance of exports from the United Kingdom in the future, it has been necessary to take this important factor in account in the long-term plans. In particular, as well as paying attention to the most economical location and economic size of unit for the mass production plants already referred to, developments in alloy and special steels from Sheffield and other areas have been fitted into the general plan. The importance of these special developments is emphasized by the fact that last year, when steel exports as a whole had increased by about 25 per cent over 1938, the exports of special steels had increased by 250 per cent over the prewar figure.

In planning steel developments in the uncertain conditions of the postwar world, considerable courage is needed, particularly in an industry where the capital expenditure in relation to production is so large. It says much for the confidence with which the British industry looks to the future that it has faced so quickly after the end of the war, the many problems involved in a large scale development plan and has been able already to get the plan well started.

II. IRON AND STEEL IN THE BRITISH ECONOMY

Steel occupies what is essentially an intermediate position in Britain's national economy. On the one hand it draws on the great raw material sources — coal mining, iron ore mining, and the collection of scrap. Also of

One of the most modern steel plants in the United Kingdom is that of Richard Thomas and Company, Ltd. at Ebbw Vale in South Wales. This is a completely integrated plant for production of sheet and tinplate, and can produce 600,000 tons of finished and semi-finished products direct from the basic raw material.



course, it makes heavy demands on the transport system for assembling vast quantities of these raw materials as well as of many other materials — limestone, refractories, etc. Then at the finishing end it provides the principal raw materials for very many of the major industries — shipbuilding, automobiles, engineering. It plays a great part in agriculture and an increasing part in house building, particularly in the provision of household equipment, and to an increasing extent in mining and other activities. It plays an important part in the export trade which is so vital to Britain and any increase necessary in present circumstances must come mainly from the steel and steel using industries. Already in 1946, 42 per cent of Britain's exports depended on steel — 10 per cent in the form of direct export of steel products and 32 per cent in the form of the products of the steel consuming industries.

This central position of the steel industry in any country's economy makes it a particularly good index of the degree of industrialization of a country. Thus, the consumption of steel per head of the population in the United States is 860 lb a year, in the United Kingdom 520 lb, in Australia 470 lb, in France 260 lb, in India 8 lb, and in China 5 lb. These figures give some idea of the great possibilities of industrial development that exist in many parts of the world.

In another sense the steel industry occupies a key position in that fluctuations of steel output provide a good and sensitive index of the welfare of the country's economy. The case with which capital development and purchases of durable goods can be postponed when the trade outlook is unfavorable means that the demand for steel falls away rapidly in periods of bad trade. Thus in five out of twenty years between the two world wars, the output of steel fell below 50 per cent of the capacity of the industry. Recently successive British governments have devoted a great deal of thought to the problem of insuring much greater stability of employment and production in Britain. It is generally accepted that the main key to the achievement of a high level of employment is to maintain a stable demand for capital equipment. This is a difficult problem and involves policies far beyond the field of the steel industry alone. Nevertheless, the steel industry in formulating a development plan for the next five years has shown the sort of forward planning of capital expenditure which, if it can be developed over a wider field, will go a long way to providing an overall stability in the item of national expenditure which was previously most subject to extreme fluctuation.

No account of the steel industry would be complete without a reference to the excellent relations traditionally obtaining between labor and management in this industry in Britain. The steel industry is one with a long tradition of craftsmanship and this had led to a deep-rooted pride in the achievements of the industry and a sense of community of interest between management and workers. The importance of this tradition is shown by the fact that no strike has originated in the industry during the last 50 years. Moreover the steel industry is traditionally one where wages and output are directly linked. The basis of most of the wage scales in the industry is the tonnage rate per unit of output so that the community of interest in maintaining quality of output is also present in maintaining quantity, to the mutual advantage of both workers and firms. The latest and most striking example of the good labor relations is the agreement between the two sides of the industry by which all melting plants, where it is technically possible, will work a continuous seven day plant week with a 48-hour week for the men on a shift system instead of closing the steel furnaces down at week-ends. This continuous week is expected to have many advantages, including an increase in output per unit of plant, and stands in striking contrast to the reduction in the working of plant in some other industries.

The problem of the relation between the State and the industry is of particular significance. On the one hand the State in Britain has entered directly into the operation of many of the public utility services. Equally, at the other end of the scale it is quite impossible to visualize any detailed operation of small manufacturing and distributive businesses by the State. In the intermediate field of the steel industry, however, the issue is a very real one. Over a period of years cooperative action within the industry has become of increasing importance. As the size of unit has become progressively larger, competition has ceased to be the sole factor governing the development of the industry and a growing factor in that development has been cooperative planning between firms. This has been an important consideration leading to the view in some quarters that the whole industry might be taken over by the State. There are grave difficulties here, arising partly from the fact that the production of steel is so closely associated with manipulation into a great variety of forms and products so that there is no clear dividing line between the steel industry and the industries concerned with the production of metal products.

As an immediate step there was set up by the British government in the autumn of 1946 an Iron and Steel Control Board, containing representatives of management, workers, consumers and the government. This body has complete authority over prices, development and other matters of policy connected with the industry. It, however, exercises only a supervisory function in relation to production, leaving to the firms the financial risk and the responsibility for the actual organization of production. This arrangement provides a machine under which public control can be operated to insure that the policies of the industry are in line with national needs; while at the same time it does not represent such a degree of centralization as will destroy the initiative, the incentive and responsibility of management of the individual firms.

The question is still under consideration whether the government will deem it necessary in the case of steel to go further and take over ownership of the industry or such parts of the industry as they feel can be separated out. Personally I should be very sorry to see the present experiment in public control abandoned in favor of public ownership before there has been a full opportunity of really testing how the arrangements now in operation will work out, but there is of course a political question on which differing views are strongly held and whose ultimate solution is a matter for settlement through the normal machinery of democracy.

PROGRAM

ANNUAL SPRING CONFERENCE

ASSOCIATION OF IRON AND STEEL ENGINEERS

APRIL 26 - 27, 1948

HOTEL STATLER BUFFALO, NEW YORK

PROGRAM

MONDAY, APRIL 26

9:00 a.m. — Registration — Mezzanine Floor

9:15 a.m. — Technical Meeting — Chinese Room
Co-Chairmen:
Bruce B. Bargman
Superintendent, Fuel
Carnegie-Illinois Steel Corporation
Munhall, Pennsylvania

E. T. W. Bailey
Combustion Engineer
Steel Company of Canada, Limited
Hamilton, Ontario, Canada

"DEVELOPMENTS IN APPLICATIONS OF CONTROLLED ATMOSPHERES TO THE ANNEALING OF STEEL," by C. E. Peck, Manager, Industrial Heating Engineering, Westinghouse Electric Corporation, Meadville, Pennsylvania.

"HEAT TRANSMISSION IN STRIP-COIL ANNEALING," by J. D. Keller, Associated Engineers, Pittsburgh, Pennsylvania.

2:00 p.m. — Technical Meeting — Chinese Room

Co-Chairmen:
C. W. Barrett
Roll Engineer
Republic Steel Corporation
Chicago, Illinois

James N. Imel
Assistant Superintendent of Rolling Mills
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania.

"PASS DESIGN AND IMPROVED METHODS TO ELIMINATE SEAMS AND SURFACE DEFECTS," by J. A. Tischbein, General Foreman of No. 18 Rolling Mill, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

"LOOPING AND REPEATING ON MERCHANT MILLS," by W. J. Barry, Superintendent of Mills, Bethlehem Steel Company, Lebanon, Pennsylvania.

"THE ART OF ROLLING FLATS," by Charles P. Hammond, Superintendent of Rolling Mills, Atlas Steels, Limited, Welland, Canada.

2:00 p.m. — Technical Meeting — Fillmore Room and Parlor E

Co-Chairmen:
I. N. Tull
Electrical Superintendent
Republic Steel Corporation
Cleveland, Ohio

2:00 p.m. — (Continued)

R. W. Graham
Electrical Superintendent
Bethlehem Steel Company
Lackawanna, New York

"NON-CONTACTING X-RAY THICKNESS GAGES FOR METAL ROLLING MILLS," by Dr. C. W. Clapp, General Engineering and Consulting Laboratory, General Electric Company, and H. S. Maxwell, Steel Mill Division, General Electric Company.

"FOUR-HIGH REVERSING COLD STRIP MILL," by Lloyd L. Wilson, Engineering Consultant, Cold Metal Products Company, Youngstown, Ohio.

"ELECTRIC EQUIPMENT FOR FOUR-HIGH REVERSING COLD STRIP MILL," by J. S. Apperson III, General Electric Company.

7:00 p.m. — DINNER — Ball Room

Speaker: R. A. Gillies, Vice President, Steel Company of Canada, Hamilton, Ontario, Canada.

TUESDAY, APRIL 27

9:00 a.m. — Technical Meeting — Chinese Room

Co-Chairmen:
F. S. Eckhardt
Chief Engineer
Bethlehem Steel Company
Lackawanna, New York

John F. Black
General Superintendent
Wickwire-Spencer Steel Division
Colorado Fuel and Iron Corporation
Buffalo, New York

"CENTRIFUGAL TUBULAR CASTINGS FOR INDUSTRY," by Earl M. Anger, Chief Metallurgist, Duraloy Company, Scottdale, Pennsylvania.

"POWER AND PRESSURE CALCULATIONS FOR ROLLING STRIP," by Frank P. Dahlstrom, Consultant, Arms-Franklin Corporation, Youngstown, Ohio.

1:00 p.m. — Inspection Trip
Bethlehem Steel Company
Lackawanna, New York

TUESDAY, APRIL 27, 1948

INSPECTION TRIP

BETHLEHEM STEEL COMPANY

LACKAWANNA, NEW YORK

Buses will leave Hotel Statler, Buffalo at 1:00 p.m., Tuesday, April 27, 1948.
Only passengers on authorized buses will be permitted to enter the plant.

TO ENGINEERS AND STEEL MILL OPERATORS . . . .

The Association of Iron and Steel Engineers is holding its Spring Conference in Buffalo this year. This is the first national meeting of the Association to be held in Buffalo since the formation of the Buffalo section.

As AISE president, I take pleasure in inviting all steel mill engineers and operators to attend the conference. One of the features of the meeting will be an inspection trip through the Lackawanna Plant of the Bethlehem Steel Company.

Your participation in the conference and its mediums of technical exchange will help you solve some of the pressing problems brought up by the efforts of the steel industry to overcome shortages. Plan to attend.

A. J. FISHER

President, AISE

PROPOSED NEW AISE CRANE SPECIFICATIONS

. . . . two major revisions are contemplated in the AISE crane specifications, gearing design and motor selection . . . . a discussion of the changes on the first item is covered in the following paper; the motor selection is covered in another paper in this issue . . . .

By I. E. MADSEN, Standards Engineer
Association of Iron and Steel Engineers

▲ THE following report will discuss primarily the proposed new gear specifications, and some minor changes in the crane specifications, and these revisions consist primarily of refinements and corrections. They are being made to allow more economical and better design, to include new refinements in design and equipment, to keep up with changes in state and other codes, and to change or clarify old clauses so as to be in accord with the crane manufacturers and users practice.

A meeting of the crane committee was held on March 24, 1946 to go over a revised crane specification which had been prepared for that meeting. One of the basic differences in the proposed motor specifications was the use of a service factor in motor selection. The use of a service factor then brought up the question of how much service a crane actually gets. In addition, a crane whose bridge may be very busy, may have a hoist which is operating only a small percentage of the time. This short time service or per cent time on for a few hours at a time is the basic factor in determining motor capacity when selecting the motor. For bearing and gearing service, the total number of cycles per year is the governing factor, and a crane which works steadily 20-24 hours a day on the average, may require a high service factor on gearing and bearings, even though the moves per hour are not large. It was therefore decided to survey crane operation before doing any more to the specifications to determine actual operating requirements. The steel industry was very cooperative in this survey, the returns covering 40 per cent of the total capacity of the industry. We now have average figures for the number of hours that hoist, trolley, and bridges operate every year, as well as the number of moves per hour and per cent time on that the bridge, trolley, hoist, and auxiliary hoist operates in an hour. So far as we know, this information has not previously been available.

Some of the more important minor revisions in the crane specifications are as follows:

Structural:

1. The clause which limits the ratio of the depth of the a box girder to 3.5 times the width is eliminated.
2. Minor changes in footwalk, railings, stairs and ladder requirements.

Electrical:

1. Bridge and trolley motor clauses will be discussed in the next paper.
2. Hoist motors will be selected on the basis of a clause as follows:

   $E = 0.93^n \times 0.98^m$ for sleeve bearing cranes.

   $E = 0.95^n \times 0.99^m$ for roller bearing cranes.

   Where n = number of pairs of gears and m = number of sheaves passed over by each rope and E = efficiency.

   The present clause states that efficiency will be taken to be 75 to 80 per cent.
3. The clause on electrical controls is being modified so that either manual or magnetic control will be used on trolley motors whose crane rating is below 20 hp. The present specification requires manual control.
4. Changes are being made in the hoist limit switch clauses to allow the use of a counterweight directly connected with the limit switch and held by suitable guides which act on the hoist cables.
5. It is proposed to allow the use of "no fuse" air circuit breakers for disconnect switches for use on crane auxiliary circuits such as crane lights, etc.
6. A clause is added that requires safety dynamic braking which will provide automatic braking upon power failure if specified on the information sheet.

Mechanical:

1. Pitch diameter of drums will be 45 times the diameter of the hoisting rope when 6 × 19 rope is used. The present ratio of 30 will continue to apply to 6 × 37 ropes.
2. Standard designs for crane track wheels, crane sheave wheels, and crane shaft couplings are being added to the specifications.
3. A new 135 lb rail has been added to the specifications.
4. Clause on press fits and keys is revised to accord with ASA specifications ASA B 17.1 — 1943.
5. Centralized lubrication systems are recognized in the new specifications.
6. The tabulation of roller bearings is being revised to accord with the new data on crane usage which has just become available. In general, required crane hours are not as high as in the old table.
7. The gearing specifications are being completely revised. This phase of the specification change will be covered in detail since these are of perhaps more importance than some of the others, and since there may be some discussion on the subject. The change also represents a fairly radical departure from the previous method of design.

The new AISE gear specifications are based directly on the American Gear Manufacturers standards as far

as they are directly applicable, and are extended in a few minor details where appropriate AGMA standards were not available. The specifications were developed in cooperation with the open gearing committee of the AGMA of which Mr. C. R. Burrell is chairman. These specifications are AGMA recommendations and should not be construed as being an AGMA crane gearing standard.

These new AISE gear specifications are set up on the basis of various hardness combinations. This arrangement will allow the user to select case hardened, oil, water, and brine quenched, flame hardened, and untreated gears. The rating varies with the hardness of gear and pinion.

The new gearing specifications read as follows:

A. Gearing shall be straight spur, herringbone, helical, or worm as specified on the information sheet. Gearing shall be designed and manufactured to comply to current AGMA gear proportion standards unless otherwise stated.
   1. Where worm gear is specified, the design and loading shall be in accordance with standards set up by the manufacturer of the worm gear.
   2. Formulae and calculations for spur gears contained in this section cover 20 degree full depth, 20 degree stub, and 14½ degree full depth tooth forms. The recommendation and trend of the gear manufacturer is to the 20 degree full depth forms. Tooth form shall be that selected by crane manufacturer unless otherwise specified by information sheet.

B. Upon release of AGMA Standard No. 241.01-Steel Gear Blanks, by the AGMA, materials for gear and pinion blanks shall be made to conform to the following items:

Material	Heat treated class	Carburized class	Surface hardened class
Forged or fabricated alloy steel	A-2	A-3	A-4
Forged or fabricated carbon steel	B-2	B-3	B-4
Cast alloy steel	C-2	C-3	C-4
Cast carbon steel	D-2	D-3	....

Heat treated gears, class 2, can be used to obtain hardness up to about 500 Brinell.

Carburized material should have a depth of case which is at least one-sixth the thickness of the tooth at the pitch line.

The following material specification will govern prior to the release of the AGMA No. 241.01. Plain pinions shall be made when possible from forgings. Gears shall, preferably, be made from fabricated steel sections welded, or solid wrought steel blanks. Gears and pinions of design and size not suitable for forging, or gears for which suitable wrought steel blanks are not obtainable shall be fabricated by welding, or cast of steel in accordance with the ASTM Standard Specifications for Carbon-Steel and Alloy-Steel Castings for Railroads, Designation A-87, latest issue. Castings shall be free from blowholes and other injurious defects.

C. Bores for gears and pinions shall be finish machined or ground to size after heat treatment.

D. Journal and bearing fits on heat-treated shafts shall be ground to size after heat treatment.

E. All keyways shall be made to conform to AGMA Keyway Standard No. 261.01, (ASA B6.6).

F. Durability and strength rating of the teeth of gears and pinions shall not exceed those derived from the application of AGMA spur gear standards to crane gearing included under paragraph J of this section. If the strength rating is the lower, it will be the governing value. In the event that the durability rating is the lower, it will govern except for Class 0, 1, 2, 3, and 4 Service Cranes. The ratings to be used for these cranes will be as follows:
   Class 0 — 0-500 hours a year — Strength horsepower.
   Class 1 — 501-1000 hours a year — Durability horsepower plus 75 per cent of the difference between the strength and durability horsepower.
   Class 2 — 1001-2000 hours a year — Durability horsepower plus 50 per cent of the difference between the strength and durability horsepower.
   Class 3 — 2001-3000 hours a year — Durability horsepower plus 25 per cent of the difference between the strength and durability horsepower.
   Class 4 — 3001-4000 hours a year — Durability horsepower.
   (These durability classifications add some extra work to the computations and may not be adopted. The above classes were added at the request of some committee members who requested that the subject be studied and a draft prepared for the next meeting.)

G. No split gears shall be used, and overhung gears, other than the armature pinion of motors cannot be used without the approval of the purchaser.

H. In the selection of the gears and pinions for the crane based on the service required, it should be noted that on the specification sheet that they should be specified by the Brinell surface hardness required. This number shall be stamped on the rim of pinions and gears to facilitate future replacement.

I. Tolerances:
   1. The following tolerances apply only to gears and pinions having a ratio of diameter to face width not exceeding 8 to 1.
   2. In all gears and pinions cut after heat treatment, or gears and pinions where no heat treatment is applied, the tolerances shall conform to AGMA gear tolerances and inspection standards No. 231.01, 232.01, and 233.01, which is also issued as ASA Standard B6.6—1946.
   3. All spur gears and pinions cut before heat treatment shall have the following maximum tolerances. All dimensions are in inches. The outside diameter used as the basis for determination of undersize, is the original outside diameter as turned, which must not be modified.

   Undersize:

   Tolerance limits from the center of the gear to the outside diameter shall be:

   +0.015 in. ÷ diametral pitch.
   —0.002 in. × pitch diameter.

   (The minus tolerance, however, shall not exceed —0.080 × the working depth of the tooth.)

   Taper of Tooth:

   The tooth surface measured at the pitch line shall

TABLE 36-I — K_1 VALUES

Allowable durability hp values — Standard 20 degree full depth tooth 1 in. face, width — 950 rpm — 5:1 gear ratio — Service factor of 1

	BHN — Pinion/Gear								
PDp	210/180	265/225	285/245	315/270	350/300	450/350	500/500	575/575	700/630
1	1.1	1.3	1.5	1.7	2.1	2.4	3.1	3.6	4.3
2	3.8	4.9	5.5	6.3	7.4	8.9	11.8	12.8	16.5
3	....	.....	.....	.....	.....	.....	.....	.....	.....
4	12.9	16.5	18.6	21.5	25.3	30.1	38.3	43.5	53.4
5	....	.....	.....	.....	.....	.....	.....	.....	.....
6	25.0	32.1	36.2	42.0	49.2	58.8	74.7	84.8	105.0
7	....	.....	.....	.....	.....	.....	.....	.....	.....
8	38.6	49.5	55.8	64.6	76.0	90.6	115.0	131.0	161.0
10	52.7	67.5	76.0	88.1	103.7	123.5	157.0	178.0	2200
14	74.9	95.9	108.0	125.4	147.0	176.0	223.0	253.0	312.0
16	82.0	105.0	118.5	137.0	161.0	192.0	244.0	277.0	342.0
18	85.0	109.0	122.8	142.0	167.0	199.4	253.0	288.0	354.0
18.14	85.4	109.4	123.4	143.0	168.0	201.0	255.0	289.0	358.0
20	82.4	105.5	119.0	138.0	162.0	193.4	246.0	279.0	345.0

TABLE 36-II — K_2 VALUES

Multiplication Factor for Correction of Gear Ratio

Gear ratio	Correction factor
1.0	0.60
1.5	0.718
2.0	0.80
2.5	0.855
3.0	0.90
3.5	0.932
4.0	0.96
4.5	0.982
5.0	1.00
6.0	1.03
7.0	1.05
8.0	1.068
9.0	1.08
10.0	1.09

TABLE 36-III — K_3 VALUES

Multiplication Factor for Correction of Face Widths

Face width	A	B	C
	Gearing for 1st reduction	Gearing for 2nd reduction	Gearing for 3rd reduction
1	1.00	1.35	1.51
2	2.03	2.67	2.92
3	2.95	3.94	4.22
4	3.87	5.16	5.56
5	4.76	6.35	6.70
6	5.60	7.46	7.86
7	6.38	8.52	8.93
8	7.10	9.49	9.94
10	8.51	11.3	11.9
12	9.62	12.8	13.5
15	11.1	14.8	15.6
18	12.1	16.2	17.1
20	13.5	18.1	19.1

If gearing is for first set of reduction, use values from Column A.
If gearing is for second set of reduction, use values from Column B.
If gearing is for third set of reduction, use values from Column C.

TABLE 36-IV — K_4 VALUES

Multiplication factor for speed correction

	Rpm								
PDp	1750	1430	950	520	230	100	56	25	13.5
1	1.697	1.439	1.000	0.580	0.270	0.122	.0691	.0312	.0171
1½	1.636	1.403	1.000	0.588	0.276	0.128	.0721	.0326	.0179
2	1.585	1.386	1.000	0.597	0.287	0.130	.0750	.0340	.0185
2½	1.550	1.363	1.000	0.608	0.296	0.135	.0777	.0356	.0195
3	1.521	1.340	1.000	0.616	0.304	0.139	.0805	.0370	.0202
3½	1.479	1.322	1.000	0.628	0.310	0.143	.0832	.0383	.0210
4	1.432	1.301	1.000	0.639	0.318	0.148	.0857	.0396	.0217
4½	1.380	1.276	1.000	0.642	0.321	0.152	.0880	.0408	.0225
5	1.359	1.258	1.000	0.655	0.331	0.156	.0914	.0425	.0233
6	1.271	1.208	1.000	0.664	0.343	0.165	.0964	.0448	.0247
7	1.180	1.159	1.000	0.689	0.360	0.174	.1021	.0477	.0263
8	....	1.108	1.000	0.701	0.377	0.183	.1081	.0505	.0282
9	....	1.056	1.000	0.725	0.395	0.195	.1150	.0539	.0300
10	....	.....	1.000	0.752	0.417	0.208	.1231	.0578	.0327
12	....	.....	1.000	0.813	0.472	0.238	.1422	.0674	.0376
14	....	.....	1.000	0.883	0.533	0.272	.1641	.0783	.0437
16	....	.....	.....	0.982	0.620	0.321	.1947	.0934	.0523
18	....	.....	.....	1.106	0.723	0.383	.2330	.1126	.0632
20	....	.....	.....	1.287	0.884	0.477	.2920	.1413	.0877

TABLE 36-V — K_5 VALUES

Multiplication factor for contact stress

Table V_A — 20 Degree full depth

Number teeth on pinion	Standard addendum teeth Gear ratio						Long addendum teeth Gear ratio	
	1:1	1.5:1	2:1	3:1	5:1	10:1	3:1	10:1
12	.....	.....	.....	.....	.....	.....	0.990	0.990
16	0.930	0.860	0.830	0.800	0.770	0.750	1.042	1.051
20	0.963	0.910	0.888	0.886	0.842	0.823	1.062	1.076
25	0.983	0.945	0.925	0.908	0.892	0.877	1.069	1.086
35	0.994	0.970	0.957	0.945	0.935	0.924	1.067	1.090
50	0.999	0.985	0.977	0.969	0.963	0.956	.....	.....
65	1.000	0.990	0.984	0.978	0.974	0.970	.....	.....

Table V_B — 20 Degree stub tooth

12	0.659	0.579	0.535	0.505	0.469	0.437	0.810	0.734
13	0.724	0.637	0.598	0.557	0.525	0.493	0.841	0.784
14	0.770	0.685	0.642	0.603	0.573	0.543	0.869	0.821
15	.....	.....	.....	.....	.....	.....	.....	.....
16	0.832	0.750	0.718	0.673	0.645	0.616	0.904	0.872
17	.....	.....	.....	.....	.....	.....	.....	.....
18	0.872	0.792	0.765	0.724	0.698	0.670	0.930	0.907
20	0.900	0.830	0.800	0.762	0.740	0.713	0.944	0.930
25	0.944	0.884	0.857	0.827	0.805	0.785	0.971	0.963
29	0.960	0.910	0.884	0.859	0.840	0.820	0.984	0.980
35	0.974	0.933	0.909	0.890	0.872	0.856	0.998	0.996
41	0.982	0.948	0.924	0.909	0.893	0.880	1.006	1.006
50	0.990	0.963	0.941	0.928	0.915	0.904	.....	.....
65	0.996	0.975	0.955	0.946	0.936	0.927	.....	.....

Table V_C — 14½ Degree full depth

	1:1 Gear Ratio Standard Add.	10:1 Gear Ratio Standard Add.	3-1 Gear Ratio Long Add.	5:1 Gear Ratio Long Add.	10:1 Gear Ratio Long Add.
12	.....	.....	.....	.....	1.108
15	.....	.....	.....	1.160	1.183
20	.....	.....	.....	1.196	1.229
24	.....	.....	1.155	1.205	1.241
31	1.000	0.975	1.160	1.204	1.244
41	1.000	1.004	1.151	1.193	1.233
50	0.998	1.018	.....	.....	.....
65	0.996	1.030	.....	.....	.....

NOTE: 20 Degree Full depth — Standard addendum teeth, addendum = 1/P. Long addendum teeth, pinion addendum = 1.5/P, gear addendum = 0.5/P.
20 Degree stub tooth — Standard addendum teeth, addendum = 0.9/P. Long addendum teeth, pinion addendum = 1.2/P, gear addendum = 0.4/P.
14½ Degree full depth — Standard addendum teeth, addendum = 1/P. Long addendum teeth, pinion addendum = 1.5/P, gear addendum = 0.5/P.
P = Diametral pitch.

TABLE 36-VI — SERVICE FACTOR

Prime mover	Duration of service	Character of load on driven machine		
		Uniform	Moderate shock	Heavy shock
Electric motor.....	8-10 Hr per day	1.00	0.80	0.57
	24 Hr per day	0.80	0.67	0.50

TABLE 36-VII — K_7 VALUES

Peak hp strength values
for
1 in. face width — 1 P — 950 rpm — Y factor of 1 — Service factor 1

PDp	BHN Pinion/Gear					
	210/180	265/225	285/245	315/270	350/300	450/350 and above
1	191.2	245.0	262.0	295.0	311.0	344.0
2	349.0	448.0	478.0	520.0	567.0	628.0
4	580.0	756.0	809.0	880.0	957.0	1062.0
6	770.0	989.0	1057.0	1149.0	1250.0	1388.0
8	922.0	1176.0	1258.0	1368.0	1488.0	1658.0
10	967.0	1240.0	1325.0	1441.0	1589.0	1738.0
12.6	992.0	1278.0	1361.0	1460.0	1610.0	1765.0
14	983.0	1262.0	1350.0	1469.0	1597.0	1771.0
16	931.0	1195.0	1279.0	1390.0	1512.0	1677.0
18	874.0	1122.0	1200.0	1306.0	1420.0	1575.0
20	765.0	980.0	1050.0	1140.0	1241.0	1377.0

TABLE 36-VIII — K_s FACTORS

Y_k factors for spur gears

Number teeth (pinion)	20 Degree pressure angle—full depth				14½ Degree pressure angle—full depth				20 Degree pressure angle—stub			
	1/1 Ratio	50 Tooth gear	100 Tooth gear	150 Tooth gear	1/1 Ratio	50 Tooth gear	100 Tooth gear	150 Tooth gear	1/1 Ratio	50 Tooth gear	100 Tooth gear	150 Tooth gear
17	0.330	0.351	0.363	0.367	.....	.....	.....	.....	0.344	0.367	0.374	0.388
20	0.346	0.366	0.376	0.380	.....	.....	.....	.....	0.364	0.378	0.390	0.402
25	0.368	0.386	0.394	0.400	.....	.....	.....	.....	0.387	0.395	0.410	0.420
30	0.390	0.404	0.410	0.417	.....	.....	.....	.....	0.405	0.409	0.425	0.433
32	.....	.....	.....	.....	0.313	0.337	0.344	0.350	.....	.....	.....	.....
35	0.410	0.419	0.424	0.431	0.322	0.342	0.350	0.356	0.417	0.420	0.435	0.444
40	0.425	0.431	0.437	0.444	0.334	0.349	0.359	0.365	0.425	0.429	0.442	0.451
45	0.438	0.441	0.447	0.454	0.344	0.355	0.366	0.373	0.433	0.435	0.447	0.458
50	0.448	0.448	0.456	0.463	0.352	0.361	0.372	0.379	0.439	0.439	0.453	0.462
55	0.457	.....	0.462	0.470	0.360	0.366	0.377	0.385	0.445	.....	0.457	0.466
60	0.463	.....	0.468	0.476	0.367	0.370	0.382	0.391	0.451	.....	0.462	0.470
70	0.475	.....	0.478	0.487	0.379	0.379	0.391	0.400	0.461	.....	0.469	0.476
80	0.484	.....	0.487	0.497	0.390	.....	0.398	0.409	0.470	.....	0.475	0.482
90	0.493	.....	0.495	0.505	0.399	.....	0.403	0.416	0.478	.....	0.480	0.486
100	0.501	.....	0.501	0.512	0.408	.....	0.408	0.422	0.485	.....	0.485	0.490
125	0.520	.....	.....	0.525	0.426	.....	.....	0.432	0.498	.....	.....	0.499
150	0.536	.....	.....	0.536	0.441	.....	.....	0.441	0.506	.....	.....	0.506

Addendum =1/P
Dedendum =1.157/P
Working depth =2/P
Hob edge radius =0.24/P

Addendum =1/P
Dedendum =1.157/P
Working depth =2/P
Hob edge radius =0.20/P

Addendum =0.8/P
Dedendum =1/P
Working depth =1.6/P
Hob edge radius =0.304/P

be parallel with the axis of the gear within 0.0001 × pitch diameter, per inch of face, but shall not exceed 0.003 × the working depth of the tooth per inch of face.

The total taper of width of face shall not exceed 0.018 × the working depth of the tooth.

4. All straight bevel gears and pinions shall conform to the tolerance limits specified above for spur gears. Determination for bevel gears is made by using the diameter of the crown circle for determination of undersize, and the cone center for determination of "taper of tooth."
5. All helical and herringbone gears and pinions shall conform to the tolerance limits specified above for spur gears. In the case of gears of these types, the taper of the tooth shall be determined from the helix angle. Determination for gearing of these types shall be considered to cover the full face in the case of single helical gears, and for half of the net total face in the case of herringbone gears.

J. Gearing shall be designed in accordance with AGMA standard Rating—"Surface Durability of Spur Gears"—210.01, December, 1946, and AGMA Standard Rating "Strength of Spur Gear Teeth" 220.01, December, 1946 or gearing shall be so designed that the following ratings (based on AGMA Standards) for durability and strength are not exceeded:

Allowable Durability $Hp = K_1 \times K_2 \times K_3 \times K_4 \times K_5$ —for 20 degree pressure angle.

$Hp = 0.75\, K_1 \times K_2 \times K_3 \times K_4 \times K_5$ — for 14½ degree pressure angle.

Allowable Peak Strength $Hp = \dfrac{K_3 \times K_4 \times K_7 \times K_8}{\text{diametral pitch}}$

Values for K_1, K_2, K_3, K_4, K_5, K_7, K_8 factors, will be found in Tables 36-I, 36-II, 36-III, 36-IV, 36-V, 36-VII, and 36-VIII of this section.

The appropriate service factor given in Table 36-VI will be applied to the Hp formulae above in computing the horsepower. Above formulae are based on a continuous contact to the tip of the pinion tooth. Where tip relief is employed, contact stress factor K_s may be recalculated based on the actual line of action.

Ratings apply to enclosed gear drives or open gears, but mounting must be sufficiently rigid to reduce deflections to a minumum. Ratings are based on proper lubrication. AGMA standards limit pitch line velocity of spur gears to a maximum of 3500 feet per minute.

Minimum Brinell hardness of spur pinions and mating gears is to be in accordance with one of the standard combinations shown in the table for K_1.

The actual load and not the rating of the motor or prime mover is to be used in computing the horsepower. Where the torque varies over one revolution of the gear, the peak transmitted torque will be used. If brake torques are in excess of the maximum driving torque, the brake torque will be used in the horsepower computation. In the event that the maximum load is a continuous load, a factor of ½ will be applied to the allowable peak strength horsepower.

The preceding sentence concludes the crane gear specifications as they are actually written. There are in addition several tables which are used in the design. Actually, the designer can take the AGMA design standards and use them directly. However, for the convenience of those who may not have the AGMA specifications, the formulae and tables which are in the crane specifications were developed for their convenience.

The first table gives a factor called K_1, but which is actually the allowable durability horsepower value for a 20 degree gear and pinion, with a one inch face width, a 5:1 gear ratio, and running at 950 rpm. It should be pointed out at this time that the allowable values for the 14½ degree tooth form are only three-fourths that of the 20 degree.

The remaining factors in the formula are primarily correction factors. The second table gives a correction factor if the gear ratio is other than 5 to 1. The third table gives a factor to use if the face width of the gear is other than one inch. This is closely proportional to the width of the gear. Since the horsepower varies with the speed of the drive, the fourth table gives a factor which is to be used if the speed is other than 950 rpm. This factor is approximately proportional to the speed. The fifth factor is a correction for contact stress. The five factors are then simply multiplied together, and the resultant value is the durability horsepower.

If the application is such that shock loads are present, a shock load service factor given in Table VI is applied.

The strength horsepower is figured in just the same manner. A table of K_7 values gives the peak horsepower strength for a given gear reduction for each size pinion and hardness of gear, which horsepower is again figured for a 1 in. face width, 950 rpm, and a one pitch gear. The corrections for speed and face width are applied as in the durability formulae, and another factor K_8 is taken from a table to take into account the stress concentration at the root of the fillet. If the pitch of the gear is other than one pitch, the result is divided by the diametral pitch.

The durability equations are based on the endurance limit in compression for the steel at the contact point between the gear and pinion. The stress is the computed maximum stress as determined by elasticity equations. The Brinell hardness is used as a measure of the endurance limit. In the strength calculations, the allowable stress is the endurance limit in tension for peak loads. The endurance limit stress is in turn roughly one half the ultimate tensile strength. Thus there is a ratio of two between the tensile strength and the maximum tensile stress at the peak load, and a factor of four between the ultimate stress and maximum tensile stress for continuous loads. This is not the same as the factor of safety, as the Y factor which has been computed for the gears takes into account the maximum stress concentration and the gears are so designed that this peak stress concentration figure is not exceeded. The value of this factor varies from about 1.4 to 3.0.

The method is quick and simple. Since there are some who do not agree to this statement, this discussion will be concluded by figuring an actual example, both by the new proposed method, and by the old. It is easily seen that there is no appreciable difference in the computation time.

Let us take, for our example, the first reduction on a crane hoist which is to handle a 50 ton load at 30 fpm at 90 per cent efficiency.

$$\text{Hp} = \frac{(100{,}000)\ (30)}{(0.9)\ 33{,}000} = 100 \text{ hp}$$

Then let us take a 100 hp motor (60 min rating), which has a speed of 460 rpm at 100 hp.

Let us assume two reductions with the first reduction having a ratio of 5.06 to 1. In the first reduction, the pinion has 19 teeth, the gear has 96 teeth, and both are 3 pitch and 20 degree stub gears. The face width is 3 in., and the pitch diameter of the pinion is 6.33 in. Try 500 Brinell

Now the

Hp (durability) = $(K_1)\ (K_2)\ (K_3)\ (K_4)\ (K_5)$

From Table I, K_1 for 6 in. diameter pinion and 500 Brinell is 74.7 hp.

K_1 for 8 in. diameter pinion and 500 Brinell is 115 hp.

$$\text{Interpolate } K_1 = 74.7 + \frac{(115\text{–}74.7) = 40}{(3)\ (2)} = 74.7 + 6.7$$

$$= 81.4$$

From Table II, $K_2 = 1.00$ (Directly)

From Table III, $K_3 = 2.95$ (Directly)

From Table IV, K_4 = 6 in. pinion = 0.343 at 230 rpm and 0.664 at 520 rpm

$$K_4\ (460 \text{ rpm}) = 0.343 + \frac{(230)}{(290)}$$

$$(0.664\text{-}0.343) = 0.343 + 0.255 = 0.598$$

Interpolating other way since pinion is actually 6.33 in.

$$K_4 = 0.598 + 0.007 = 0.605$$

From Table V, $K_5 = 0.698$—18 tooth pinion

$K_5 = 0.740$—20 tooth pinion

or $K_5 = 0.721$—19 tooth pinion

Durability hp = (81.4) (1.00) (2.95) (0.605) (0.721) = 105 hp.

This gear is satisfactory for the contemplated service from a durability standpoint. Actually, in practice it would not have been necessary to work out all the interpolations since they can be done in your head, and the difference may be minor.

We will now check for strength.

$$\text{Hp} = \frac{K_7\ K_3\ K_4\ K_8}{\text{Diam pitch}}$$

$K_7 = 1388$ for 6 in. pinion

$K_7 = 1658$ for 8 in. pinion

$$K_7 = 1388 + \frac{1}{(3)\ (2)}\ (1658\text{-}1388) = 1388 + 45 =$$

1433 hp.

$K_8 = 0.385$ interpolating between 0.374 for 17 teeth and 0.390 for 20 teeth.

$K_3 = 2.95$ (From durability computation)

$K_4 = 0.605$ (From durability computation)

$$\text{Strength hp} = \frac{(1433)\ (2.95)\ (0.605)\ (0.385)}{3} = 330$$

This is much greater than the durability or wear horsepower. Wear horsepower will normally be the governing factor.

In the event you should wish to take the economy of a service factor into consideration: let us suppose this crane is classified as Class 3.

Then allowable horsepower = 103 + 0.4 (330-103) = 103 + 90 = 193 hp.

As a comparison, let us compute the allowable horsepower by the old specifications:

$$\text{Pitch Line Velocity} = (460)\ \pi \frac{(6.33)}{(12)} = 765 \text{ fpm.}$$

From Table J of old specification:

Allowable load 600 Brinell, 700 fpm = 4320 lb.

Allowable load 600 Brinell, 800 fpm = 4010 lb.

Allowable load 600 Brinell, 765 fpm = 4320-0.65 (4320-4010) = 4320-200 = 4020.

Allowable load 240 Brinell, 700 fpm = 1820
Allowable load 240 Brinell, 800 fpm = 1690
Allowable load 240 Brinell, 765 fpm =
1820-0.65 (1820-1690) = 1820-85 = 1735
Now interpolate for 500 Brinell

$$\text{Wear load} = 1735 + \frac{(500\text{-}240)}{(600\text{-}240)}\ (4020\text{-}1735)$$

$$= 1735 + 1650 = 3385 \text{ lb.}$$

Since this is a 3 pitch gear and tables are made up for one pitch gears one inch wide:

$$\text{Wear load} = \frac{3385}{3} \times 3 = 3385 \text{ lb.}$$

$$\text{Hp} = \frac{(3385)\ (765)}{33{,}000} = 79$$

This is the allowable wear horsepower by the old method, and it is interesting to note that the more exact design method allows a load which is 32 per cent greater, when wear is the criterion.

We will also figure the strength value by the old method.

From Table H of old specification:
fy—700 fpm = 0.178
fy—800 fpm = 0.165
fy—765 fpm = 0.178-0.165 (0.778-0.165)
= 0.178-0.008 = 0.170
Going back to Table H for fy = 0.170 and the B_2 gear which is 600 Brinell, since the table is not worked out for 500 Brinell.

Tooth load = 3740 per inch of face for one pitch gear

$$\text{Tooth load} = \frac{3740 \times 3}{3} = 3740$$

$$\text{Hp} = \frac{(3740)\ (765)}{33{,}000} = 87$$

This value is much less than that previously computed by the newer method.

Before closing, I want to point out that these proposals have not been officially adopted, and changes may be made in the final specifications. The chief purpose in presenting them at this meeting is to show what is being considered and to obtain comments before the next crane committee meeting. It is expected that the final draft of these specifications will go to the crane committee for their action together with any comments or suggestions for changes which are received as a result of this meeting.

In conclusion, I wish to thank Mr. Clarence Burrell, and Mr. F. Richardz, as well as the other AGMA members who worked on these specifications, and the steel mill men who furnished the data on crane operation which form the basis of the crane service tables in the crane specifications.

DISCUSSION

PRESENTED BY

F. M. HIGHBARGER, Engineering Supervisor, Carnegie-Illinois Steel Corporation, Gary Works, Gary, Indiana

I. E. MADSEN, Standards Engineer, Association of Iron and Steel Engineers

F. RICHARDZ, Manager, Gearing Engineering Department, Westinghouse Electric Corporation, Pittsburgh, Pennsylvania

F. H. Highbarger: Would it be possible to have Mr. Madsen present the specifications as set up by the Chicago district of Carnegie-Illinois Steel Corporation?

I. E. Madsen: After I wrote this report I received a proposal from some of the men in the Carnegie-Illinois Steel Corporation on what they would like to see in the new gear specifications. This new proposal you can summarize briefly as follows: Figure gears for strength only. Do not consider the wear requirement that we had in our old specifications. The strength figures that we would use, would be based on the method just illustrated on the blackboard for strength. However, due to the fact that our old gear specifications do not include the 20-degree full depth, Mr. Highbarger's group has worked out the Y values and the other values which are necessary in figuring the gear strength values of 20-degree full depth teeth.

In addition, the allowable fiber stresses which were used with the strength values in the old specifications may have been inconsistent, and they have reworked these values.

Our old specification is given in a table. This group has also been able to take the table, apply it in a curve or plot form, which makes it easier to use than the table, and enables one to go to a chart and pick the allowable values out of the chart.

F. Richardz: There is not much that can be amplified in this paper and the only thing that could possibly be added is an explanation of the differences between the AISE and the AGMA horsepower for strength. The reason for the difference is that the present AISE specifications are using a much lower design value which is not exactly uniform over the range in regard to the hardness or the ultimate strength of the material, whereas the AGMA, in their practice, are using the endurance limit consistently on the basis of material hardness with correction for surface-hardened gears.

It should also be remembered that what Mr. Madsen has presented as an AGMA proposal is purely on the basis of uniform load and requires an application factor suitable for the particular type of crane being considered. On the equivalent basis to the present AISE, it would require an approximate factor of 4. However, this factor would not be uniform. The allowable stress based on hardness as indicated in the present AISE is, for example, 16,000 pounds per square inch for a 241 Brinell which amounts to a factor of 3.7 on the endurance limit or, roughly, 8 on the ultimate. The AGMA practice does not apply a factor of this magnitude for speed reducer gearing. The proposed AGMA practice must, therefore, be tempered with a service application factor, and I believe that Mr. Madsen has canvassed the crane industry and is now working up a proposed application factor suitable for the industry.

MOTOR SELECTION FOR EOT CRANES

. . . . this method of determining motor sizes, developed for consideration by the AISE EOT Crane Specifications Committee was given as an oral report at a Standardization Session of the 1947 AISE Annual Convention . . . . it was later presented in a more complete form as a conference paper at the January 27, 1948 Materials Handling session at the AIEE Winter meeting . . . .

By M. A. de FERRANTI, Engineer
Materials Handling and Testing Equipment Division
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Schenectady, New York

INTRODUCTION

▲ THERE is an increasing demand for the application of mill type motors on d-c cranes, both for steel mills and for heavy duty in other industrial plants. Although no radical changes have taken place in the design of series wound d-c motors, it is well with the adoption of new standards for d-c mill motors to review their operating characteristics and to determine how these affect their application to cranes. It is well also to emphasize that the standards adopted by the Association of Iron and Steel Engineers eliminated some of the methods of rating previously used on mill motors. Open discussion of these changes by engineers interested in the materials handling industry is the surest way to avoid misapplication, and to take full advantage of the characteristics built into the new mill motor.

D-C SERIES WOUND MILL MOTOR CHARACTERISTICS

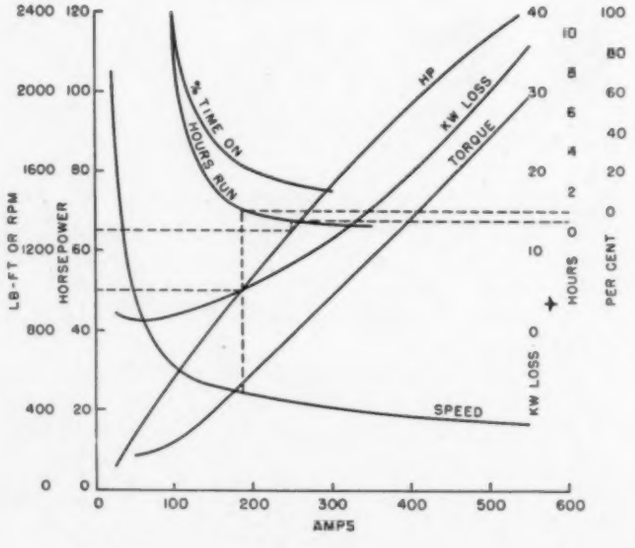
Figure 1 shows the characteristics of an MD-610 d-c series wound mill motor which is typical of this form of the new line recently standardized by the Association of Iron and Steel Engineers. These new motors are already being applied extensively on both steel mill and other heavy duty cranes. Note particularly that no rating is given in the title of this figure because in order to apply the motor correctly, a clear understanding of the characteristic curves is necessary. Knowledge of a nameplate rating representing a single point on the horsepower curve and a corresponding point on the speed curve is not sufficient to make a correct application of the motor. Data given by curves in the figure, however, are sufficient to apply the motor intelligently and predict its performance.

Some data which are readily determined from this figure will bear emphasis by the following comments:

1. The maximum running torque for the motor is 2100 lb-ft.
2. The maximum safe speed of the motor is 2100 rpm.
3. If run continuously at constant load, this totally enclosed motor will develop 27 hp without exceeding 75C. At this load its speed will be 630 rpm and therefore its torque will be 225 lb-ft.
4. If run for 60 minutes continuously at constant load the motor will develop 50 hp without exceeding its guaranteed temperature rise. At this load its speed will be 500 rpm and therefore its torque will be 525 lb-ft. If operated on repeated cycles, each of not more than 5 minutes duration, the portion of the total time during which it could be run and carry 50 hp would be 23 per cent.
5. The motor could run with a constant load of 65 hp for 30 minutes without exceeding guaranteed temperature rise. On repeated cycles, each of not more than 5 minutes duration, the portion of each cycle it could be running and carry 65 hp would be 14 per cent.

Similar information could be determined for other load or time conditions and the motor could theoretically carry any one or all of these ratings on its nameplate without any change in the motor itself. From

Figure 1 — Motor characteristic curves for MD-610, 230V, series wound motor.



Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 24, 1947

practical considerations it is desirable to use the minimum number of nameplate ratings, but make all operating data available to those in a position to apply the motor. Whether the motor be in its totally enclosed form, its protected self-ventilated form, or its enclosed forced ventilated form, the speed, torque and horsepower curves of the motor are the same. Regardless of the nameplate rating on the various forms of the d-c series wound mill motors, the maximum running torque and commutating peaks to which the machine may be subjected are the same. The thermal ability of the motor changes, however, with the various forms and consequently its ability to handle duty cycle operation.

Methods of connecting and controlling the motor so as to modify the speed torque characteristics of the motor and adapt them to crane operation have been previously discussed. It is not the intention here to discuss in detail the control equipment used or the methods of calculating speed torque characteristics, but a brief review of the principal methods of modifying the speed torque characteristics of the series motor is essential to the correct application of motors to crane drives.

The simplest method of reducing motor torque (not torque per amp) and speed output of a series motor is by addition of resistance in series with the motor. The effects of various values of such resistance are shown by Figure 2. One hundred per cent resistance for a particular motor application is that value of resistance which, with rated voltage applied, and with the armature at standstill, will allow rated motor current to flow. It will be recognized, therefore, that the value representing 100 per cent resistance will vary with the various possible ratings of the same physical motor. For example, if the MD-610, 230 volt motor bears a one hour rating of 50 hp, the rated current is 184 amp. Then 100 per cent resistance is 1.25 ohms. However, if the same motor bears a 30 minute, 65 hp rating, the rated full load current would be 246 amp and 100 per cent resistance is 0.935 ohms. The curves shown in Figure 2 are based on the 30 minute ratings of MD-600 motors. The dotted speed-torque curve corresponds to the dotted connection of shunting the series field. This connection provides a method of securing speeds higher than provided by the basic curve of the motor, and it is seldom used in crane applications of series motors. Note that none of the curves in this figure cross the zero torque axis, indicating that the motor speed may become excessive if load torque falls too low.

Further modification of the speed torque characteristics can be effected by the addition of armature shunting resistance. Figure 3 shows speed torque curves for a series motor having various combinations of line and armature shunting resistances. It will be noted that the addition of armature shunting resistance gives the motor a positive maximum speed, even when load is entirely removed from the motor. The armature shunted connections provide improved speed regulation even at light loads and these connections are especially suitable for slowdown points without resorting to plugging the motor. Figure 4 shows the shunt motor connection of a d-c series wound motor using various values of line, armature and series field resistance — this connection provides dynamic braking and regenerative braking, and is particularly adaptable to control of overhauling

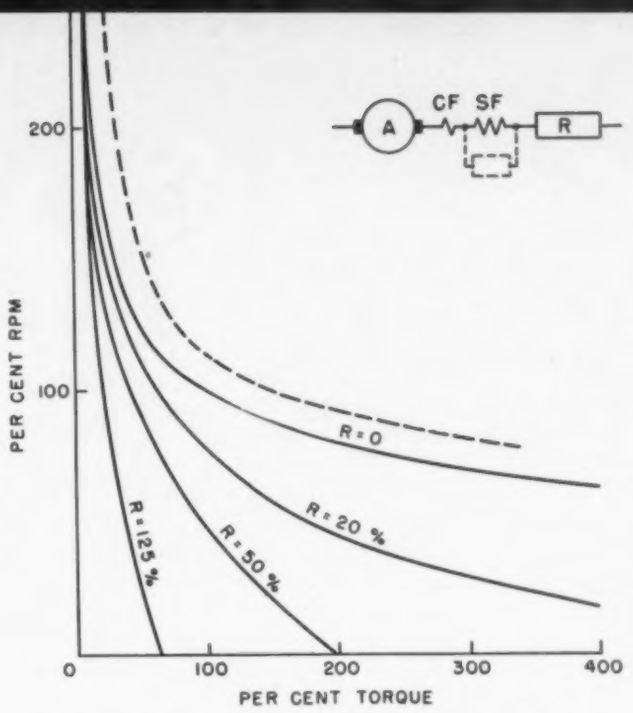


Figure 2 — The addition of line resistance reduces the torque of a d-c series wound motor as shown.

loads. Figure 5 combines the curves of Figures 2, 3 and 4 to show how they may be used to give the features necessary in hoist control of a d-c series wound motor. It is not intended that this represent an actual layout of a crane hoist system, but rather that it show the type of curves which are required to satisfy the speed torque relationships shown in the schematic diagrams showing directions of motion and of motor torque for each quadrant. The solid line arrows indicate direction of motion of the load. The dotted line arrows show direction of torque.

HOIST MOTOR AND GEAR RATIO SELECTION

For many years d-c series wound crane motors and d-c series wound mill type motors have been successfully applied to hoist motions of cranes on the basis that the ½ hour horsepower rating of the motor should be not less than the horsepower required to hoist specified hook load at specified hook speed. A review of factors which may affect this practice and consideration of the new mill motors in this respect follows:

The advent of roller bearings on motors and hoists, together with other design improvements which have increased the mechanical efficiency of hoists, emphasizes the problem of excessive light hook speeds. Selection of hoist gear ratio should be made carefully, and care should be exercised to avoid overmotoring. As will be demonstrated by a sample calculated below, overmotoring may well cause excessive light hook speed, with the attendant possibilities of overrunning the upper limits. With the elimination of the ½ hour rating of mill type d-c motors by the Association of Iron and Steel Engineers, it is important that electrical engineers realize the relationship between the one hour rating which the motor bears and the crane hoist load to which it may be applied. Table I shows a comparison of the 60 minute ratings and 30 minute capacity of the line

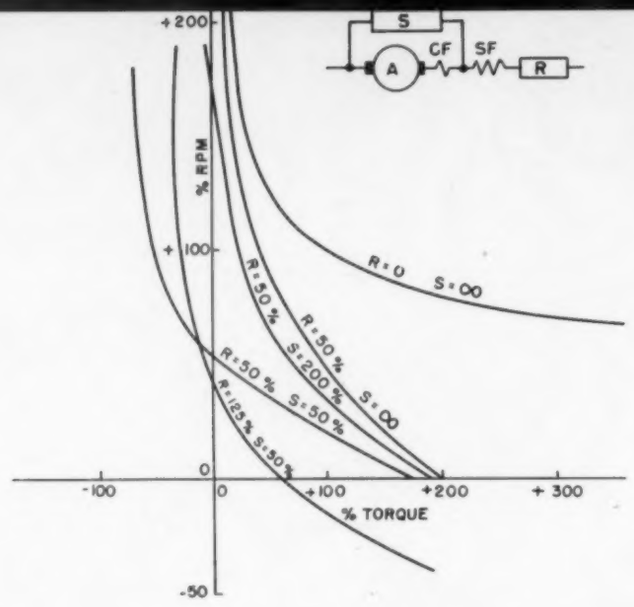


Figure 3 — Effect of line and armature shunting resistance on speed-torque characteristics of d-c series wound motor.

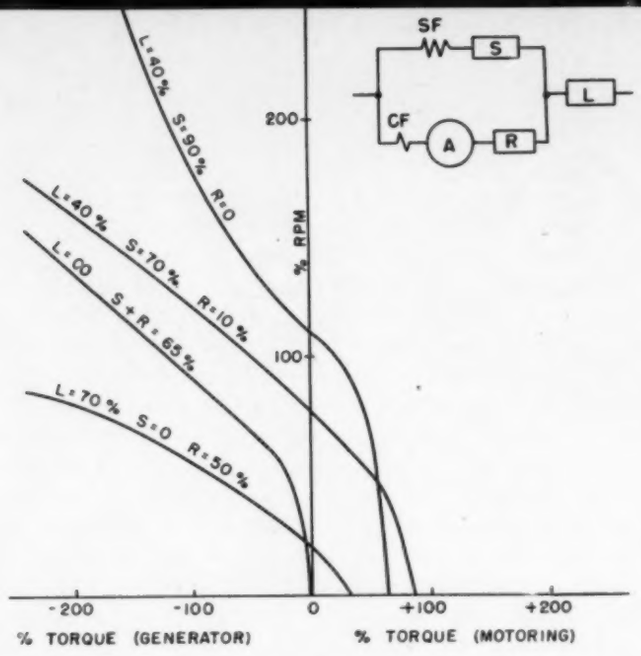


Figure 4 — Speed-torque characteristics of d-c series wound motor when operated as a shunt motor.

of new totally enclosed d-c series wound 230 volt mill motors:

Suggestions have been made that d-c series wound motors bearing a 30 minute rating should continue to be applied on crane hoist motions so that horsepower output of the motor does not exceed this rating when the hook is hoisting specified load at specified speed. For mill type motors bearing a 60 minute nameplate rating, the horsepower load on the motor should not exceed 1.33 times the nameplate rating when the hook is hoisting specified load at specified speed. In general terms, mill type d-c series wound motors should be applied to crane hoists so that the torque loading on the motor, when the hook is hoisting specified load at specified speed is not greater than 40 per cent of the motor's maximum guaranteed running torque. For example, consider the application of a d-c series wound mill type motor to the hoist motion of a crane, on which the following data apply:

Weight of hook with specified load..... 31,000 lb
Specified hook speed..... 50 fpm
Mechanical efficiency of hoist..... 0.85

Then the horsepower output of the motor to hoist specified load at specified speed is given by:

$$Hp = \frac{31{,}000 \times 50}{33{,}000 \times 0.85} = 55$$

and a d-c series wound mill motor having a 30 minute rating not less than 55 hp or a 60 minute rating of not less than $\frac{55}{1.33} = 41.3$ hp should be used. Such a motor is the MD-610 for which characteristics are shown in Figure 1. Reference to Figure 1 indicates that for a 55

TABLE I

Comparison of 60 minute rating and 30 minute capacity of d-c series wound mill motors

	Max running torque	Max running rpm	60 Min rating			30 Min capacity			Hp_{30}*	T_{30}*	T_{30}*
			Hp	Rpm	Lb-ft	Hp	Rpm	Lb-ft	Hp_{60}	T_{60}	T_m
MD-602	196	3600	7½	800	49	10	675	78	1.33	1.59	0.397
MD-603	288	3300	10	725	72	13½	610	116	1.35	1.61	0.402
MD-604	484	3000	15	650	121	19	600	166	1.27	1.37	0.343
MD-606	912	2600	25	575	228	33	515	336	1.32	1.47	0.368
MD-608	1400	2300	35	525	350	45	470	503	1.28	1.44	0.365
MD-610	2100	2100	50	500	525	65	445	767	1.30	1.46	0.465
MD-612	3320	1900	75	475	830	100	430	1220	1.33	1.47	0.368
MD-614	4560	1700	100	460	1140	135	400	1775	1.35	1.55	0.390
MD-616	7000	1600	150	450	1750	200	400	2630	1.33	1.50	0.362
MD-618	10,000	1500	200	410	2560	265	385	3620	1.32	1.41	0.362

* The last three column headings have the following significance.

$\frac{Hp_{30}}{Hp_{60}}$ is the ratio of the 30 minute hp capacity to the 60 minute hp rating of the motor.

$\frac{T_{30}}{T_{60}}$ is the ratio of the 30 minute torque capacity to the 60 minute torque rating of the motor.

$\frac{T_{30}}{T_M}$ is the ratio of the 30 minute torque capacity to the maximum torque ability of the motor.

hp output the MD-610 series wound motor has a speed of 480 rpm and that if operated on repeated cycles, each of 5 minutes or less, the motor may carry this load for 19 per cent of the total time. Gearing should be selected so that 480 rpm on the motor shaft corresponds to 50 fpm speed of the hook. By calculation or from the torque curve of Figure 1 the motor shaft torque corresponding to specified load on the hook is 600 lb-ft. Assume that when hoisting an empty hook the motor torque is reduced to 15 per cent of the full load hoisting torque, i.e. to 90 lb-ft. Then from the speed and torque curves of Figure 1 it will be noted that motor speed is 900 rpm which means that the light hook will travel up at 187 per cent of specified speed, i.e. at 93.5 fpm.

Table II considers the use of several different motors on the hoist drive of this example:

Note from this tabulation that, if severe duty on the hoist requires more thermal capacity than provided by the totally enclosed MD-610, there are several ways in which this can be secured:

1. Use of the same frame size but changing to the protected, self-ventilated form of the mill motor. This increases the "per cent time on" from 19—57 for the 55 hp load without any change in speed torque characteristics.
2. Use of the same frame size but with the force-ventilated features including motor driven blowers mounted on the mill motor and with or without filters. This increases the "per cent time on" for the 55 hp load to 85 per cent without any change in speed torque characteristics.
3. By the use of the next larger frame size (612) of totally enclosed series mill motor the per cent time on for the 55 hp load and on duty cycle work is 43. However, the light hook speed is higher as a percentage of specified speed, and because the Wk^2 value of the larger motor is higher, the stored energy in the motor armature when hoisting with a light hook is almost three times that for the MD-610 in any one of its three forms. The significance of this high stored energy not only lies in the increased energy which must be supplied to the motor, but of more importance is the fact that this must be dissipated in order to stop the hook in its upward travel. This causes increased duty on the motor if dynamic braking is used, and also increases the duty on holding brakes which are set very rapidly when making a stop of travel in the hoisting direction. Especially does this increase of stored energy become an important factor in the selection and setting of the overhoist limit switch.

In addition to the above alternative selections of new 600 series motors, two ratings of type CO enclosed, series wound crane motors have been tabulated. The CO-1830 high speed motor would handle the 55 hp load from a torque standpoint but for the low torque required to hoist a light hook this motor would reach an unsafe speed. These high speeds are reached only if the hoisting distance is sufficient for the motor to accelerate fully. The use of a larger (CO-1831) motor gives safe light hook speeds but it is interesting to note that the stored energy during light hook operation is considerably less with the MD-610 than with either of the CO motors. Also, it is clear from the low "per cent time on" values for the CO motors that these are not as good for duty cycle operation as the mill type motors.

Although "per cent time on" values are an accurate indication of the motor's ability to handle duty cycle operation, when the load throughout the "time on" is constant, the watts loss method of determining the thermal capacity of the motor must be used when the load varies during the "time on." This method has been publicized by manufacturers of the mill and crane type motors and consists briefly of the following:

Determine from the motor characteristic curves the watts loss for each value of load, then compute the total watt seconds loss during the "time on" period, and determine the average watts loss over this same period. The "per cent time on" corresponding to this value as shown by the motor curve should be greater than the percentage ratio of the running time to total cycle time. For force ventilated d-c mill motors operating on duty cycles, current values for the various loads during a cycle can be determined from the motor characteristic curve and an rms current value determined for the total cycle time (full ventilation is provided both when the motor is running and at rest). If this is less than the current corresponding to the motor's continuous rating which is equal to the 60 minute rating of the enclosed motor, the cycle can be repeated continuously without overheating the motor.

TABLE II

Comparison of mill and crane motors for hoist drive

Motor	Form	30 Min capacity or rating	60 Min rating	Rpm at 55 hp	Permissible per cent time on at 55 hp	Wk_2	Motor rpm for light hook	Per cent of specified hook speed	Stored energy in motor. Hp sec Light hook up
MD-610	Enclosed	65 hp-445 rpm	50 hp-500 rpm	480	19	72	900	187	18.2
MDP-610	Protected		62½ hp-460 rpm	480	57	72	900	187	18.2
MD-610	Separate blower	Continuous rating 50 hp-500 rpm		480	85	72	900	187	18.2
MD-612	Enclosed	100 hp-500 rpm	75 hp-475 rpm	550	43	118	1200	218	53.0
CO-1830	Enclosed	65 hp-700 rpm	47 hp-850 rpm	760	7	52.4	2100	*276	72
CO-1831	Enclosed	75 hp-500 rpm	55 hp-600 rpm	600	12	95.2	1450	242	62.5

*This speed exceeds the safe maximum speed for the CO-1830 motor.

The inherent speed torque characteristics of d-c series wound motors are particularly suited to the acceleration of heavy masses such as crane bridges and trolleys. The use of the motor in conjunction with series resistance provides a convenient means of limiting the accelerating torque peaks during acceleration and also controlling deceleration by plugging the driving motors. By the addition of an armature shunting connection, it is possible to provide a positive maximum speed and also give the travel good slowdown and creeping speed characteristics. The subject of control and methods of calculating resistance layouts for designed speed torque curves lies outside the scope of this paper, but the general features and effect of various values of resistance are shown by Figure 6. This shows the four speed-torque quadrants and indicates schematically the direction of motion and of motor torque for each quadrant. It can be seen that the motor and resistor connections shown provide all of the features required for control of the bridge or trolley motion.

The selection of the correct series motor rating and gear ratio to give the required rates of acceleration and guaranteed running speed is affected by many variables. With changes in mechanical design, particularly the use of anti-friction bearings, and with the adoption of new standards for d-c mill motors, it seems desirable to review some of the factors which determine the selection of d-c series motors for bridge and trolley drives.

The force necessary to drive the bridge or trolley consists of that necessary to overcome rolling friction and that required to accelerate or decelerate the crane. The rolling friction is proportional to the total weight and is assumed to be constant at all speeds of travel of the bridge or trolley; it is generally expressed in terms of pounds per ton weight of the bridge or trolley and in the following analysis is denoted as "f." The force required to accelerate the bridge or trolley is equal to its mass times its rate of acceleration. The acceleration is denoted as "a" and is generally expressed in terms of feet per second per second. These are two of the variables (f and a) which enter into any consideration of bridge and trolley drives.

The function "f" is determined by the mechanical design of the crane and rails and varies from values as high as 30 lb per ton for some sleeve bearing drives down to as low as 6 lb per ton for some roller bearing drives which have been tested. The rate of acceleration "a" refers, in the case of d-c bridge and trolley drives, to that part of the acceleration when the motor has resistance in series, and which is being cut out in steps by magnetic contactors or by a drum switch. During this period several steps of control are provided to give an average constant torque until all resistance is cut out, and after that accelerating rate is determined by the characteristic curve of the motor. The accelerating rate maintained by the average constant torque produced by the motor, while on the resistor, is the maximum which occurs during acceleration. This value is limited by considerations of wheel slippage, hook swing, and operator comfort (for cab operated cranes) and is more significant than any average which might be taken over the full time for the drive to come up to speed.

Corresponding to these linear forces, the torque delivered to the driving wheels of the bridge, by the motor, comprises that necessary to overcome rolling friction and that required to accelerate the mass of the bridge. These torques, expressed as Tg and Ta respectively, are both functions of the bridge weight and for the range of rolling friction and accelerating rates encountered in practice can be combined into a single factor. This factor also takes into account the approximately constant shape of the speed-torque curve for all ratings of series wound MD-600 motors. It also takes into account the upper limit of torque to which the motor may be subjected while the accelerating resistor is in the circuit. Experience has indicated this upper limit of torque as 200 per cent of the 60 minute torque rating of the motor, which is 133 per cent of the 30 minute torque rating, or 50 per cent of the maximum running torque of the motor.

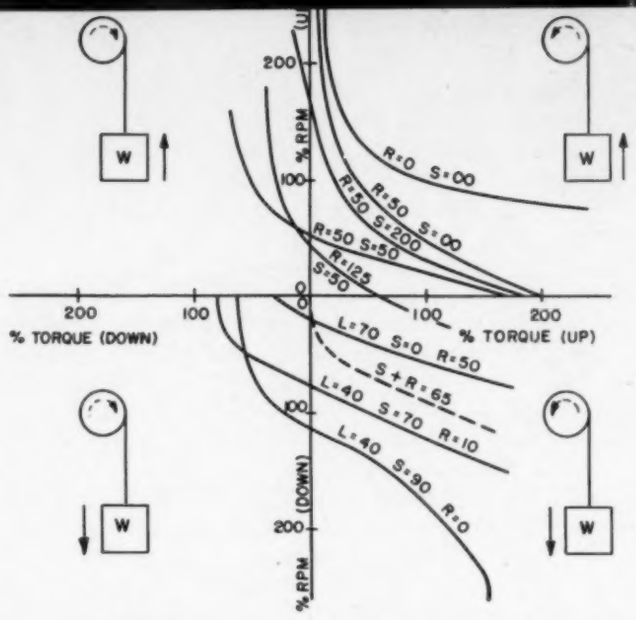


Figure 5 — Speed-torque characteristics of d-c series wound motor operating hoist motion of crane.

The single factor known as the accelerating factor (k_a) also includes the numerical constants necessary to convert our variables to horsepower rating. This k_a factor is developed in Appendix A of this paper, and its values for practical conditions of rolling friction and accelerating rate are shown in Figure 7.

As developed in Appendix A, it is possible to use these k_a factors to determine the minimum horsepower rating of a suitable enclosed type MD series wound bridge motor by the formula

$$\text{Hp (60 min)} = \frac{k_a \times W \times V}{E} \text{ in which}$$

W is the bridge weight in tons (including load), V is the specified bridge speed in feet per minute, and E is the mechanical efficiency between driving wheels and motor shaft.

The factors reviewed above and a simple example of bridge motor selections are shown in Figure 8.

The formula above will give the theoretical minimum horsepower rating of the enclosed MD motor required. The nearest standard rating above this value should be used. After selecting the standard enclosed MD motor, gearing should be selected by computing the free running horsepower, and then referring to the characteristic curves of the actual motor to be used. Corresponding to the free running horsepower value, read

the motor speed and then select gear ratio so that this corresponds to specified bridge speed.

Thus far the selection does not take into account heating of the motor, but before discussing this it will be well to review an example of motor selection by the above formula.

Consider an overhead steel mill crane which has a total weight of 77 tons when loaded, and has a specified bridge speed of 350 fpm. Assume that the mechanical efficiency between axle and motor shaft is 0.9, the rolling friction is 21 lb per ton and that the accelerating rate required while on the resistor is 2 fpsps. From Figure 7 the Ka factor is 0.00160. Then

$$\text{Hp (60 min)} = \frac{\text{Ka WV}}{\text{E}}$$

$$= \frac{0.00160 \times 77 \times 350}{0.9}$$

$$= 48.0$$

This calls for an MD-610—50 hp—60 min rated motor.

$$\text{Now free running hp} = \frac{77 \times 21 \times 350}{33{,}000 \times 0.9}$$

$$= 19.5$$

Referring to the characteristic curve of MD-610 motor, Figure 1 indicates that the corresponding speed is 770 rpm.

The motor torque at this point (which is Tg in the derivation) is:

$$\frac{19.5 \times 5250}{770} = 133 \text{ lb-ft}$$

The 60 min torque rating of this motor is 525 lb-ft and by definition it may be used at twice this value while accelerating the bridge on the resistor, i.e. at 1050 lb-ft. Then the torque available for acceleration:

$$= 1050 - 133 = 917 \text{ lb-ft}$$

Approximate torque to accelerate motor rotor and brake wheel is as follows:

Wk^2 of motor = 72; Brake wheel = 24 approximately. Speed when resistor is cut out is approximately $\frac{350 \times 0.8 \times 500}{770}$ fpm = 182 fpm. Time to reach this

$$\text{speed} = \frac{182}{60} \times \tfrac{1}{2} = 1.5 \text{ sec}$$

$$\text{Torque to accelerate motor and brake} = \frac{96 \times 400}{308 \times 1.5}$$

$$= 83 \text{ lb-ft}$$

Therefore, net torque available for bridge acceleration = 917—83 = 834 lb-ft. The corresponding force Fa available for acceleration is given by equation (7) of Appendix A as $\text{Fa} = \frac{2 \text{ Ta GE}}{\text{D}}$ and by selection of gearing such that 770 rpm motor speed corresponds to 350 fpm. Then $\frac{\text{G}}{\text{D}} = 6.91$ and Fa = 10,400 lb. Consequently a =

$$\frac{\text{F} \times g}{\text{W}} = \frac{10{,}400 \times 32.2}{154{,}000} = 2.17 \text{ fpsps}$$

which is a little better than specified.

For a determination of the motor's ability to meet a particular frequency of operation, there is no accurate method except a duty cycle calculation. A typical duty cycle calculation for a bridge drive using the MD-610 motor is given in Appendix B.

Conclusion

The above review of series mill motor characteristics and the examples given demonstrate that the mill motors may be applied to crane motions on the following basis:

1. For hoist drives the smallest enclosed motor applied should be such that the hp required to hoist specified load at specified speed is not greater than the 30 minute capacity of the motor. This is equivalent to 1.33 times the motor's 60 minute hp rating and the corresponding motor torque is approximately 40 per cent of the maximum running torque of the motor.
2. For bridge or trolley drives the smallest enclosed motor applied should be such that its 60 minute rating is not less than that given by formula:

$$\text{Hp (60 min)} = \frac{\text{K}_a \text{ WV}}{\text{E}} \text{ or}$$

the 30 minute rating should be not less than 1.33 times this.
3. In both cases the motor selection should be checked from a heating standpoint, if repeated duty cycles are to be performed. Except for borderline cases, the motor characteristic curves give sufficient information to make such a check, and the motor manufacturers are always ready to make a check of any application on which complete data is available.

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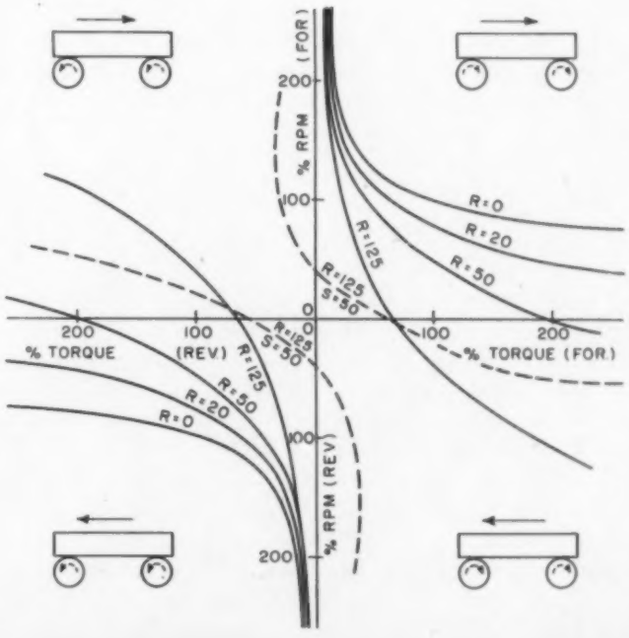
5. *Basic Procedures in Motor Control, Part 1. D-C Series Motors,* General Electric Review, May, 1947.

Figure 6 — Speed-torque characteristics of d-c series wound motor operating bridge or trolley motion of crane.



APPENDIX A

DEVELOPMENT OF Ka FACTORS

The force at the axles, Fg, necessary to move the bridge at constant speed against a rolling friction of f in lb per ton is:

$$Fg = Wf \text{ lb} \quad (1)$$

where W = total weight in tons of bridge (including load) and if the specified speed of the crane is V feet per minute. Then the free running horsepower (Hp_g) to drive the crane is expressed by:

$$Hp_g = \frac{WfV}{33{,}000 \times E} \quad (2)$$

where E is the mechanical efficiency between the axles and the motor shaft. Corresponding to the force Fg there is a motor torque Tg. The gear ratio of the drive must be such that the speed of the motor when its output is Hp_g corresponds to specified bridge speed V. The motor speed corresponding to the free running horsepower output can be determined from the motor characteristic curve, when the rating has been selected. This speed is denoted as Ng.

Also note that since this fixes the gear ratio, the relationship between V and Ng, may be stated as:

$$V = \frac{Ng}{G} \times \pi D \quad (3)$$

where D = diameter of truck wheel in feet.

G = total gear ratio between truck axle and motor shaft (thus for a crane with 3 reductions such as 15/61, 13/37 and 17/39, the total gear ratio G is 26.55)

The force at the axles, F_a, necessary to accelerate the bridge at a rate of acceleration of "a" feet per second per second is:

$$F_a = \frac{2000\ W}{g} \times a \text{ lb} \quad (4)$$

where "g" is acceleration due to gravity.

Corresponding to the force F_a there is a motor torque T_a.

In general form, therefore, the total force F, to accelerate and propel the bridge is given by:

$$F = F_g + F_a \quad (5)$$

$$= Wf + \frac{2000\ W}{g} a$$

$$= W\ (f + 62a) \quad (6)$$

The torque T (corresponding to F) at the shaft of a driving motor mounted on the bridge is equal to $T_g + T_a$ and is related to F in the following manner:

$$T = F \times \frac{D}{2} \times \frac{1}{G} \times \frac{1}{E} \text{ lb-ft} \quad (7)$$

$$= \frac{W}{E}\ (f + 62a) \times \frac{D}{2} \times \frac{1}{G} \text{ lb-ft} \quad (8)$$

This torque is that which must be supplied by the motor while on the resistor. Experience in application of series motors to drives of this type indicates that the maximum running torque of a suitable motor should not be less than twice torque T. In terms of motor ratings, this means motor torque T should not be greater than twice the 60 minute torque rating or 1.33 times the 30 minute torque rating of the driving motor. Based on the information given by equation (2) and equation (7) and keeping within the above limit selection of a suitable motor could be made by a system of trial and error, but this is rather tedious. As a matter of fact, several empirical formulae, such as selecting a motor having a 30 minute rating, three or four times the free running horsepower, have been set up at various times, but it is found that these break down for certain combinations of "f" and "a" factors.

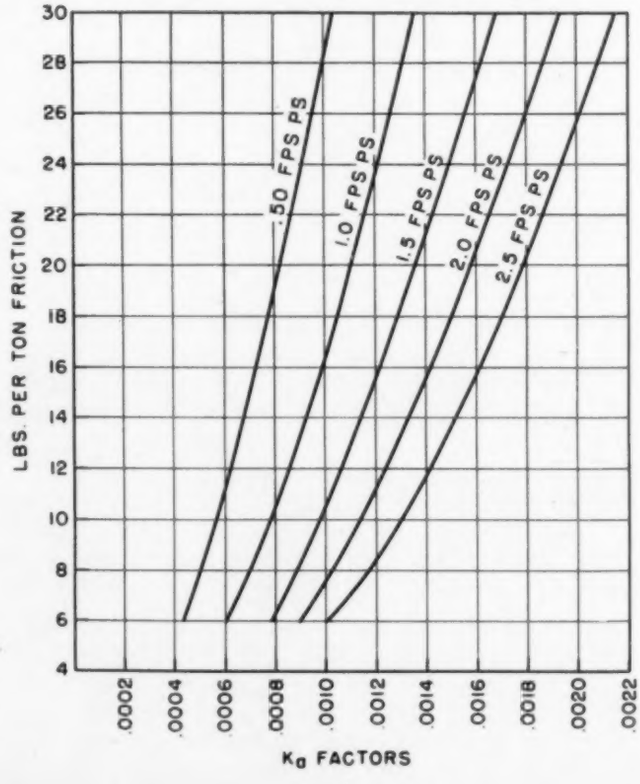
A review of the speed torque curves for the complete line of new MD-600 series motors indicates that if plotted on a per cent (or per unit if preferred) basis, the values are so close that a single curve can be used for the whole line of series wound motors. The curve of Figure 8 has been drawn to represent the shape of the speed torque characteristic of any MD-600 series motor which may be selected for a bridge drive. Point G on the curve represents free running condition and the motor speed Ng, at this point, corresponds to the specified speed V of the bridge when full loaded. Then if the motor is applied to its full capacity in accordance with the torque limits set up above, and with gearing as prescribed by point G, then motor torque to accelerate the bridge at specified rate "a," while motor is on the resistor, is represented by point A. This corresponds to twice the 60 minute rated torque of the motor and to 80 per cent of the 60 minute rated speed.

In general terms, from the curve in Figure 8 the following holds true regarding Hp_r, the 60 minute rating of the motor, which corresponds to 100 per cent speed and 100 per cent torque:

$$Hp_r = \frac{N_R \times T_R}{5250} \text{ horsepower} \quad (9)$$

$$Hp_r = N_R \times \frac{(T_g + T_a)}{2} \Big/ 5250 \quad (10)$$

Figure 7 — Ka factors for various values of friction and accelerating rates on crane trolleys and bridges.



and from equation (8)

$$Hp_r = \frac{N_R}{10{,}500} \times \frac{W}{E}\left(f+62a\right) \times \frac{D}{2} \times \frac{1}{G} \qquad (11)$$

The ratio of N_R to N_A is fixed just as T_R to T_A is fixed by our definition, but the ratio N_R to N_g varies according to the ratios of T_g to (T_g+T_a) and correspondingly to f and a, and this can be independently determined for various values of these variables.

$$\text{Now } N_R = N_g \times \frac{(N_R)}{(N_g)}$$

and from equation (3)

$$N_R = \frac{VG}{\pi D} \times \frac{(N_R)}{(N_g)} \qquad (12)$$

Substituting this in (11) gives

$$Hp_r = \frac{VG}{10{,}500\pi D} \times \frac{(N_R)}{(N_g)} \times \frac{W}{E}(f+62a) \times \frac{D}{2} \times \frac{1}{G}$$

$$Hp_r = \frac{WV}{E} \times \frac{(N_R)}{(N_g)} \times \frac{(f+62a)}{66{,}000} \qquad (13)$$

The term $\frac{(N_R)}{(N_g)} \times \frac{(f+62a)}{66{,}000}$ is the accelerating factor and can be computed for various values of a and f and from the shape of the speed torque curve, as follows:

Corresponding to the ratio $\frac{N_R}{N_g}$ there will be a ratio of the corresponding torque, i.e. $\frac{T_R}{T_g}$

$$\text{and } \frac{T_R}{T_g} = \frac{\frac{T_g+T_a}{2}}{T_o}$$

which, considering equations (7) and (8)

$$= \frac{(f+62a)\quad \frac{WD}{2\ G\ E}}{2f\quad \frac{WD}{2\ G\ E}} = \frac{f+62a}{2f}$$

or in per cent terms (remembering that $T_R = 100$)

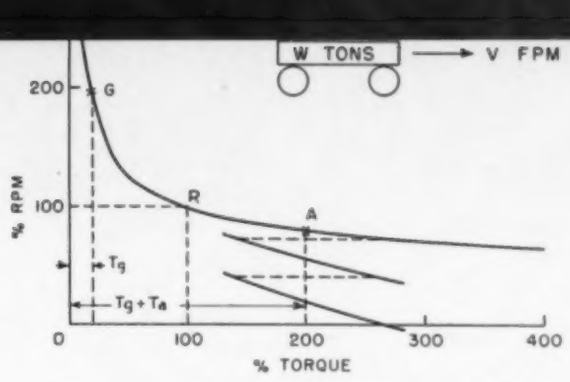
$$\%T_g = \frac{200\,f}{f+62a}$$

and for various values of $\%T_g$, a value of per cent N_g can be read from the basic curve (Figure 8) and the ratio $\frac{N_R}{N_g}$ (remembering that $N_R = 100\%$) becomes $\frac{100}{\%N_g}$

As an example, the K_a factor for a crane bridge which has 12 lb per ton friction, and is required to accelerate at 1 foot per second per second, while the motor is on the resistor, will be determined as follows:

$$f+62a = (12+62 \times 1) = 74$$

$$\%T_g = \frac{200\,f}{(f+62a)} = \frac{200 \times 12}{74} = 32.5$$



1 HOUR HP RATING OF TROLLEY MOTOR = $\frac{K_a WV}{E}$

EXAMPLE - W = 154 TONS V = 300 FPM E = .8
f = 12 LB PER TON a = 1.0 FPS PS K_a = .00086
∴ HP (1 HOUR) = 50

USE MD-610

FREE RUNNING HP = $\frac{W \times 12 \times 300}{33000 \times .8}$ = 21

Figure 8 — Selection of d-c series wound motor rating and gear ratio for hoist and trolley drives of crane. Gearing is selected to give V fpm for motor rpm of 730 at 21 hp taken from motor curve.

and from the basic curve Figure 8.

$$\%N_g = 144$$

$$\frac{N_R}{N_g}\ \frac{100}{\%N_g} = 0.695$$

$$\text{and } \frac{N_R}{N_g}\ \frac{(f+62a)}{66{,}000} = \frac{0.695 \times 74}{66{,}000} = 0.000775$$

One factor which has not been taken into account and would tend to increase the torque required to assure the accelerating rates specified is the inertia of the motor and brake wheels. This varies but generally lies somewhere between 4 and 10 per cent of the bridge inertia when put on the same base. Therefore, the K_a factors as deduced above have been increased by a factor of $\frac{1}{0.9}$ and for the example above:

$$K_a = \frac{0.695 \times 74}{66{,}000 \times 0.9} = 0.000865$$

K_a is then calculated similarly for all practical combinations of a and f and plotted as curves in Figure 7.

As demonstrated by Table I, the ratio of the 30 minute rating to the 60 minute rating of d-c mill motors is approximately 1.33 to 1.0 and therefore the corresponding 30 minute rated motor which would operate in the same manner as prescribed above would be given by multiplying the above result by 1.33. Then the final formula for giving the minimum rating of motor for a bridge or trolley drive may be written:

$$H_P \text{ (60 minute)} = \frac{Ka\ WV}{E}$$

$$\text{or } H_P \text{ (30 minute)} = \frac{1.33\ Ka\ WV}{E}$$

APPENDIX B

MOTOR HEATING CALCULATIONS

To figure heating of the motor, the duty cycle on which the crane will operate must be predicted. For

example it will be assumed that the crane considered in the example under bridge and trolley drives makes repeated bridging motions such that the bridge accelerates to free running speed and is then decelerated by a hydraulic brake. The load is then removed from the hook and the crane returned to its starting point.

Assumptions

Crane specified load	= 15 tons
Crane weight including load	= 77 tons
Specified bridge speed	= 350 fpm
Rolling friction per ton	= 21 lb
Accelerating rate while on resistor	= 2 fpsps
Mechanical efficiency	= 0.9

Gearing and motor rating will be as previously determined, namely MD-610, and G/D = 6.91.

Calculations

The equivalent Wk^2 value of bridge at motor shaft $= \frac{154{,}000}{0.9 \times 39.6} \frac{(350)_2}{(770)} = 895$ lb-ft²

Adding motor and brake $WK^2 = 991$ lb-ft²

With the above information, and reference to the motor characteristic curves, it is now possible to calculate time, distance travelled and motor losses during acceleration of the bridge from standstill to full speed. This will be done in steps as follows:

1. With motor on resistor i.e. from 0–400 rpm on motor.
2. From 400 to 500 rpm on motor.
3. From 500 to 600 rpm on motor.
4. From 600 to 700 rpm on motor.
5. From 700 to 770 rpm on motor.
6. From 770 rpm to 0 on motor shaft. Deceleration by hydraulic brake. Motor disconnected.

This is computed for the outward trip of the loaded crane and the return trip of the unloaded crane.

1. 0 to 400 rpm

While on resistor average motor torque
is twice 60 minute rated torque = 2 × 525 = 1050 lb-ft
Free running torque = 133 lb-ft
Net torque available for acceleration = 917 lb-ft

Time to accelerate to 400 rpm $= \frac{991 \times 400}{308 \times 917} = 1.4$ sec

Average bridge speed $= \frac{350 \times 400}{770 \times 2} = 91$ fpm

Distance traveled $= \frac{91}{60} \times 1.4 = 2.13$ ft

Average motor loss (from curve) = 13 kw
Total loss during acceleration = 13 × 1.4 = 18.2 kw sec

2. 400 to 500 rpm

Corresponding bridge speeds = 182 to 227 fpm
Average bridge speed = 204.5 fpm

Average motor torque $= \frac{1050+525}{2} = 787.5$ lb-ft

Net accelerating torque = 787.5—133 = 654.5 lb-ft

Time to accelerate $= \frac{991 \times 100}{308 \times 654.5} = 0.491$ sec

Distance traveled $= \frac{204.5}{60} \times 0.491 = 1.67$ ft

Average motor loss (from curve) = 8.5 kw
Total loss during acceleration = 4.18 kw sec

Similarly subsequent increments can be computed and the results are shown in Table III.

For the return trip, the equivalent Wk^2 value of the bridge and the free running torque are reduced corresponding to the dropping of the load. Also there will be some full speed running of the unloaded crane to cover the full return distance.

TABLE III
Duty Cycle Calculation

	Rpm	Final fpm	Avg fpm	Time on-sec	Total sec	Feet traveled	Total distance	Avg kw loss	Kw sec
Out trip-loaded									
Accelerate on resistors	0-400	182	91	1.4	1.4	2.13	2.13	13	18.20
Accelerate on motor curve	400-500	227	204.5	0.495	1.895	1.67	3.80	8.5	4.18
Accelerate on motor curve	500-600	272	249	1.195	3.090	4.95	8.75	3.5	4.20
Accelerate on motor curve	600-700	318	295	3.32	6.410	16.30	25.05	2.0	6.64
Accelerate on motor curve	700-770	350	332	13.65	20.060	75.60	100.65	1.5	20.50
Decelerate on brake	770-0	0	175	2.92	22.98	8.50	109.15	0	0
Return-unloaded									
Accelerate on resistor	0-400	182	91	1.13	1.13	1.72	1.72	13	14.70
Accelerate on motor curve	400-500	227	204.5	0.39	1.52	1.33	3.05	8.5	3.32
Accelerate on motor curve	500-600	272	249	0.897	2.417	3.72	6.77	3.5	3.14
Accelerate on motor curve	600-700	318	295	2.160	4.567	10.60	17.37	2.0	4.32
Accelerate on motor curve	700-850	386	352	10.90	15.467	64.00	81.37	1.3	14.20
Run at full speed	850	386	386	3.71	18.177	17.43	98.80	1.1	2.98
Decelerate on brake	850-0	0	193	3.22	21.397	10.35	109.15	0	0

Total time for round trip = 44.377 sec
Total kw seconds loss = 96.38 kw sec
Motor "time on" = 20.060 + 18.177 = 38.237 sec
Average kw loss = 2.52
Allowable "per cent time on" = 50 for an average kw loss of 2.52 from curve, Figure 1.
Time per cycle = 76.475 seconds, required if motor is not to overheat.

Time available for deceleration, lowering and raising hook, loading and unloading during each cycle = 38.237 seconds, which is 50 per cent of the total cycle time. Approximately 47 round trips per hour can thus be made without overheating the motor and this may be carried on continuously.

With the data given in the tabulation, speed-time, and speed-distance diagrams may be plotted for the bridging motion of the crane. This is particularly desirable for consideration of other cycles which may be performed by the same bridge drive.

Maintenance Methods Symposium

By

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STEAM TURBINE INSPECTION AND MAINTENANCE

By H. A. SMITH

▲ STEAM turbines have been in operation at the South works plant of Carnegie-Illinois for about 40 years. During this period approximately 155,000 horsepower in turbines have been installed with practically every make and type represented.

The first two turbine units installed in 1906 were a 2000 kw horizontal turbogenerator at No. 2 power station and a 2000 kw vertical turbogenerator at No. 3 power station. Both were operated with 150 pound steam slightly above saturation temperature.

The second major turbine installation was made in 1910, consisting of one 7000 kw vertical mixed pressure generating unit at No. 3 power station and two 3000 kw horizontal mixed pressure turbogenerators at No. 2 power station. The 7000 kw turbine was operated on 150 pound pressure steam and four pound exhaust steam from the blast furnace blowing engines and the steam engine driven electric power generators. The 3000 kw units were operated with 150 pound pressure steam from coal fired boilers and four pound exhaust steam taken from three rolling mill engines and routed through steam regenerators.

In 1931, two 10,000 kw horizontal turbogenerators were installed at No. 4 power station. These turbines are operated on 250 pound pressure and 675 F temperature steam supplied by No. 4 open hearth waste heat boilers. Stage bleeding is employed on these turbines for feed water heating, with a closed system of boiler feed water.

The last major installation was made in 1937 at No. 5 power station, consisting of one 25,000 kw horizontal turbogenerator and three 8550 hp turboblowers. Steam for these turbines is supplied by three combination gas and oil fired boilers at 450 pound pressure and 750 F temperature.

At present approximately 120,000 horsepower in steam turbines are in operation at South works, 79,000 of which are at No. 5 power station. The present turbines range in size from 45 horsepower to 50,000 horsepower.

A review of the inspection and maintenance of steam turbines at South works to date show that both types of the early turbines utilizing 150 pound steam and the mixed pressure units seem to have much in common. The main cause of outages on these turbines were blading and condenser trouble. The steam conditions left much to be desired since the fluctuations in load and fuel very often resulted in low pressures and wet steam. Carryover of solids and oils from the boilers, steam engines, or steam regenerators coated and damaged the blading and condenser tubes. This contamination of the steam also caused undue wear on the turbine blading.

In an attempt to reduce the turbine outage for cleaning tubes and turbine blading, a method was devised whereby the condenser, and to some degree the blading, could be cleaned without dismantling the unit. The condenser steam space was filled with a mixture of kerosene and water and steam allowed to pass through the turbine blading in order to boil the water in the condenser. The vacuum breaker valve was adjusted to prevent pressure from building up in the turbine casing. The procedure proved to be a satisfactory method for cleaning the tubes, however it did result in leakages of the condenser tube packing. The tube packing consisted of a fiber ring, followed by tightly woven soft packing, another fiber ring, and tightened with a standard tube sheet ferrule. In most cases the leakage was stopped by removing the ferrule, adding fiber rings, and replacing the ferrule.

Frequently the inside of the condenser tubes were plugged with debris, scale, or slime, and it was necessary to wash out the tubes with a jet of air and water followed with soft plugs or scraper type tube cleaner. An emergency outage was incurred approximately every six weeks for cleaning and inspecting the turbine blading and condenser.

The bearings on the early horizontal turbines were a source of considerable trouble, partly because of poor lubrication inherent in their design. Those which were the most difficult to lubricate and maintain in proper adjustment were the multicollared shaft thrust bearings. These bearings were water cooled and lubricated by oil rings requiring constant observation, since the rings

would stop rolling around the shaft and the bearing would receive no lubrication. The poor lubrication was corrected somewhat by the installation of a continuous oil cooling tank and oil return pump. The five gallons of oil in the bearing reservoir were run through the cooling tank where the circulating oil capacity was increased to 12 gallons and then pumped to the top of the bearing over the oil rings.

The couplings used on the horizontal machines were of the pin type using 6-ply rubber and canvas bushings in one half. Replacement of these bushings and pins was necessary at least once a year.

Scheduled outages for a complete inspection and overhaul were planned for these units once each year. During this outage the turbine was completely dismantled and the spindle and diaphragms removed from the casing. The blading was washed, scraped, and straightened if bent. The casing and diaphragm carbon packing shaft seals were replaced. Bearings were cleaned or replaced as required. Erosion occurring on the leaving edge of the blading, due to wet or dirty steam, was filed smooth for several years but later this was considered unnecessary. All turbine blading clearances were checked and adjusted, the governor and all auxiliary equipment cleaned and overhauled, and the coupling bushings and pins replaced. This annual outage generally consumed from two to three weeks.

Emergency outages on the present 250 pound and 450 pound superheated steam turbines are rare. Annual and biennial turbine outages are scheduled for inspection and overhaul after a definite program is outlined based on operating records and general performance.

In general, annual inspections are confined to cleaning, adjustments, and possible replacement or repair of minor parts such as: pin and fast type couplings, knife edges, bushings and pins on the governor linkage, inlet valve rods and rod packing, cleaning condenser tubes, checking the oiling system, throttle valve and emergency overspeed trip mechanism. These inspections are generally completed within a 24 hour period.

The biennial inspection, to cover all elements of the turbine and auxiliary equipment, is scheduled and planned for a 10 to 14 day period. Prior to the shutdown, representatives of the manufacturer are requested to observe the unit in operation and to discuss any major repairs anticipated. Throughout the outage a field engineer from the manufacturer is requested to assist in the supervision of dismantling, inspection and assembly of the unit.

Inventories are taken sufficiently in advance to ascertain that all replacement parts are on hand or to permit procurement of needed parts. In removing the unit from service, care must be taken to maintain the shaft deflection at a minimum. This is done, especially in the larger units, by rotating the spindle slowly with a turning gear during the cooling period. The top half of the turbine casing is removed and all blade clearances are taken and recorded on both sides of the spindle at the casing split.

The spindle is removed and a thorough check of both the casing and spindle is undertaken. All blading is cleaned, washed, and various methods of detecting cracks or flaws are employed such as whiting and penetrating oil, magnaflux, zyglo, etc. All cracks or flaws are recorded during the inspection and, the manufacturer's representative is consulted regarding any repair or replacement required.

In reassembling the unit the governor, bearings, couplings, steam valves, extraction lines, oil piping, auxiliary units, etc., are inspected and placed in good working condition. During the starting period, turbines must be warmed up slowly to prevent distortion. This is accomplished in turbines equipped with a turning gear by rolling the spindle while admitting a small amount of steam. The amount of steam passing into the turbine must be less than that required to turn the spindle at the turning gear speed. Admission of too much steam will disengage the turning gear and might result in considerable damage by rubbing, if the spindle is at all distorted. In the smaller turbines, not equipped with turning gears, sufficient steam is admitted to cause the spindle to rotate at low speed during the warming period. After the unit has been heated sufficiently and no irregularities observed, the spindle is brought up to speed. During this operation observers are stationed at various points about the turbine to record conditions, and any variations from normal are reported immediately to the operator in charge. After the unit is up to normal operating speed, the governor is tested for upper and lower speed limits and an overspeed trip test made. Everything being satisfactory the unit is then ready to be placed in service.

In conclusion, it is the writer's belief that the frequent outages in the early turbines as compared with the more modern ones were attributable primarily to the poor quality of the steam employed, and to the lubrication methods used, rather than to any shortcomings in their design. While a reasonable amount of carryover and moisture in the steam are not too objectionable in a steam engine it is imperative that the steam used in turbines be clean and dry. Although many improvements have been and still are being made in the design and material used in turbine blading as well as in the design of thrust bearings, shaft packing, condenser tubing, lubrication methods and auxiliary equipment, it is believed that the most important advancement from a maintenance standpoint has been made in the condition of the steam employed.

DISCUSSION

PRESENTED BY

C. R. DIETZ, General Foreman, Electrical Power Department, Inland Steel Company, East Chicago, Indiana

H. A. SMITH, Superintendent Power Maintenance, Power Production Division, South Works Carnegie-Illinois Steel Corporation, South Chicago, Illinois

H. W. NEBLETT, Special Engineer, Inland Steel Company, East Chicago, Indiana

C. R. Dietz: I would like to know if you take the machine apart when washing it to clean dirty, scale covered or oil soaked blading?

H. A. Smith: No. In the old time machines employing exhaust steam from the rolling mill engines this was not practical. You can imagine the amount of cylinder oil which would be carried over in the exhaust steam from these rolling mill reciprocating engines. With the type we had, it was impossible to keep the oil from going into the turbine. In six weeks time the contamination in the root of the blade from the oil would build up to where the turbine could not carry the load. It was impractical to dismantle the turbine this often, so we filled the condenser with a mixture of kerosene and water and boiled the machine out by admitting steam through the throttle. It was not a real job, but it could be done quickly when time was not available to dismantle the machine for a thorough cleaning. In more modern turbines, a certain amount of carry-over from the boilers is deposited on the blades. This can be partially removed by desuperheating the steam to saturation, and allowing the moisture in the steam to wash the blades.

C. R. Dietz: We did that in 1913 but received cylinder oil in the blading. We then used kerosene and it was satisfactory until oil got around the outside of the condenser tubes and plugged the condenser. How would you clean that?

H. A. Smith: We filled the condenser with a mixture of kerosene and water and heated it with inlet steam. By allowing sufficient time, the kerosene solution actually boiled in the condenser and removed most of the oil and contamination.

C. R. Dietz: We could not get ours clean that way and had to go to acid.

H. A. Smith: As I mentioned previously, this method did not do a complete job of cleaning. It partially cleaned the unit and prolonged the interval between extended outages when it was completely dismantled and cleaned. I think I mentioned in my talk that in this particular type of turbine using low pressure steam from the rolling mill engines routed through the regenerator, that we also tried installing lubricators on the stages and feed in a solvent of sugar beet compound to clean the blades. Neither of these methods more than partially cleaned the unit. The only way we could really clean it was to dismantle the unit.

C. R. Dietz: The torch oil cleaned the blading of cylinder oil, but the cylinder oil plugged the condenser, and to remove this cylinder oil we had to use 33 lb of muriatic acid with one barrel of water. It took 22 barrels of this solution to fill the condenser which was agitated with steam and left in for four hours. This cleaned the tubes perfectly, however, you had to be careful you did not use too much acid.

H. A. Smith: That acid may cause trouble some day. I would suggest you wash the unit with a soda ash solution after removal of the acid. Drawing a comparison between these turbines and the modern units, most of these troubles have disappeared. We have turbines on which we have not cleaned the condensers in ten years. These condensers have nothing on the outside of the tubes which would effect the heat transfer. This is due, of course, to better steam conditions. We do experience contamination on the inside of the tubes from the dirt in the circulating water, but this is not serious enough to warrant cleaning more than once a year.

C. R. Dietz: We had a 20,000 kilowatt turbine less than 10 years where the ammonia effect found in the condensate of the air ejectors had deteriorated the outside of the condenser tubes. The most modern power plants throw the condensate from the air ejector away.

H. A. Smith: An ideal turbine installation would be one very similar to what we have at our No. 4 power station. This station employs a closed system between the boilers and turbines, and practically no make up is required. The condensers on these turbines have not been cleaned since 1939 and are in perfect condition despite the fact that the units have been in service continuously except for 24 hour outages annually, and 10 day outages biennially. If you are interested, I will be glad to show you the record of these turbines.

H. W. Neblett: Some two years ago, I was assigned the topic "The Maintenance of Turbines," by the AISE Standardization Committee and you probably noticed that a rather concise report was given on that about the first of this year. I covered the subject generally by stating that in general the modern turbine could operate with an inspection only every two years provided external inspection was carried on at regular intervals and these inspections did not disclose any unusual conditions. I was glad to hear Mr. Smith say the modern turbine could go two years between internal inspections.

MILL BEARINGS AND LUBRICATION

By FRANK B. GOLLEY

▲ IN the short period available it will be possible to indicate only some of the maintenance problems and changes tending to correct those problems that have occurred in our plant in recent years. Primary mill bearings for many years, were either babbitt or brass, and were oil or grease lubricated. The tonnage obtained from these bearings was not too satisfactory and costs were relatively high. It is not so long ago when the operator was presented with new types of bearings, namely the roller bearing, and the phenolic resin type or composition bearing. Many mills are now equipped with the composition type bearing and much of the following has no doubt been duplicated in operating experience in other plants. It was about 1934 that a change was made from the babbitt bearings on the 40 in. blooming mill to the composition type bearings. At that time this was quite a departure from regular practice. A change such as this is often reluctantly made by reason of the rather high first cost, and the question in the operator's mind as to the worth of the newer type. In the changeover it was necessary to reroute the water piping to the mill, in order that the cooling water for the rolls was separated from the cooling water for the bearings. This was done in order to insure adequate and continuous water supply for the new type bearing, and as absolutely essential. The bearing was designed with separate liner and collar. Reasonable success was obtained with the first installation, and after all concerned became more familiar with the requirements of this type of bearing, bearing life

was increased to approximately 4 or 5 times that of the old babbitt bearing. In fact on one bottom liner exceptionally long life was obtained, the tonnage on this liner being 960,000 tons. The bearing was put in at $\frac{31}{32}$ in. thickness and taken out at $\frac{3}{16}$ in. thickness. On the average, bearings are now taken out at $\frac{3}{8}$ in. thickness, the tonnage obtained being considered satisfactory at that point.

It has been our experience over the years that the success of this type of bearing is directly proportional to the care taken of the mill, the care taken of roll necks, and of the bearing installation. Experience indicated early that it was necessary to maintain reasonably good alinement of the equipment involved. For example, where it was unnecessary or rather unusual with babbitt bearings to line up the center line of the rolls with that of the pinions, and then line up the spindle between the rolls and pinions, it was now found to be essential. When roll bearings or spindle bearings are changed, it is necessary to adjust the spindle carrier to obtain reasonably close alinement. It was found necessary to reline the chocks often enough, to maintain straight line contact, both on the thrust face and the side of the chock. Practically no difficulty from scale has been experienced due to an effective scale guard for the bottom roll. The edge of the guard nearest the roll is circular, and has a flange which fits over a shoulder cut in the roll. It had been noted that even when babbitt bearings were used that the top shell on the spindle side of the mill wore twice as fast as the opposite side of the mill. This remained true after the composition bearings were put into service, as it was found that there were more failures and greater wear on the spindle side of the mill. This being particularly true in the summer when the cooling water temperature increased. It was recognized that this was due to an unbalanced condition of the hydraulic balance for the top roll. A simple and satisfactory means of correcting this condition was finally evolved. This consisted of inserting four steel blocks between the top chock and carrier on this side of the mill, but slightly larger than the normal opening between them, with the roll in place. This resulted in no pressure on the neck when running idle. As the bearing wore, it was of course, necessary, to change the thickness of the blocks. The collars used on this mill do not last the life of the liners, average experience indicating the use of two collars to one liner. This is due to the fact, that the rollers tend to pull up tighter than necessary when setting up the mill, and to the fact that as the rolls are thrust contact area changes and some grinding of the collar is required to obtain proper contact and adequate bearing area. Collars go in at $1\frac{1}{2}$ in. in thickness, come out at $\frac{7}{8}$ in. in thickness.

It should be apparent from what has been said above that often with the installation of the new type bearings considerable greater care was taken than before, of the bearings, chocks, etc. Many times we have wondered, whether with the same amount of attention, the old babbitt bearing might have given better life and performance than it did. Recent developments in the use of this material has been the use of composition slippers on the mill end of the mill spindles. These slippers have been able after some change in design, to meet successfully the conditions prevailing in this mill, and have proved to be more economical than the previous hardened steel slipper, precisely as the hardened steel slipper had been more economical than the original bronze slipper. This type of slipper results in a quieter mill, and because of a lower original cost, less wear is allowed between slipper and spindle, and a better mechanical condition results. It might be assumed that a change to this type of material would result in a considerable less wear on the spindle. Somewhat less wear was experienced, but the improvement was not anywhere near what was first thought possible. These slippers are grease lubricated by hand during delays, and have proved quite satisfactory. It is just as important that these slippers be adequately lubricated as any other type. Though it has been claimed that lubricating requirements are less critical than with metallic slippers, our application has not substantiated this claim. It has been found that without adequate lubrication there has been scoring of both the spindle socket and the spade of the roll. While ideal conditions dictate starting out with a newly reconditioned socket when installing a new slipper, we have been able to apply them in a used socket that has a taper ranging from $\frac{1}{8}$ in. at the top inside diameter of the socket down to 0.00 in. at the pin hole point. The maximum wear permissible to either the spindle socket inside diameter or the slipper outside diameter or both is $\frac{5}{16}$ in.

Last year, composition bearings were installed in the mill tables on the idler end of the table rolls. This changeover was a simple matter, the flange of the bearing being eliminated, and the bearing formed to fit into the oil pocket to prevent end motion. The bearing cap was drilled from the end, and the water runs from the cap around, and lengthwise of the journal, and out through a plug, originally used to remove the oil from the oil pocket. The former bearings were of special bronze and were oil ring lubricated. The bronze bearings cost about $60 each and the average life obtained was about 75,000 tons. It should be stated that these bearings are located where it is difficult to lubricate them, and where considerable scale penetrates into the bearing. The new type bearing costs about $40 and the test bearing has run 400,000 tons. It has been found that where considerable trouble before was encountered from scale finding its way into the brass bearings, now no trouble occurs from this source. It has been found also that less maintenance is required of the table roll necks which formerly were severely scored.

In 1937, an expansion program was completed which resulted in the construction of a 32 in. bloomer and a 21 in. continuous mill. These mills were equipped with the phenolic resin type bearings. The table roller bearings, shear bearings, etc., were roller bearings. Table roll roller bearings in our experience have been quite satisfactory, the greatest difficulty is found where the table rolls become eccentric. These roller bearings appear to stand considerable shock, and in the main the original bearings are still in use. However, the bearings have been run to the point where there is as much as $\frac{1}{16}$ in. wear between rollers and race, and without failure. These bearings need positive and regular lubrication.

This is accomplished by a modern lubricating system serving some 450 points. From the operator's viewpoint, a good lubricating system should provide an adjustable amount of lubricant to each bearing, and such lubricant

should be positively delivered to the bearing at frequent stated intervals. The operator is interested in a system that will function without failure, of course, but when failure occurs, is interested in determining the place of failure as quickly as possible. The system in use, installed when the new mill was put in, has proved satisfactory.

Since the time many years ago when the first mill was put into operation, lubrication has been an important factor in successful mill operation. Successful lubrication of any equipment requires sufficient, and not more than sufficient lubricating medium applied at the proper place at the proper time. In years gone by, this was the sole function of the oiler, generally the lowest paid man in the mechanical group. With this sort of a setup frequent campaigns were needed to insure proper performance on the part of the oiler, continual check was required of his work, and yet there was a continual succession of improperly lubricated bearings. It is true in our plant, and I assume in many others, that certain parts of the mill still require lubrication by an oiler. It has been our experience that an oiler is about as effective, as his training, and the interest aroused in him by that training to do a proper job. Therefore, for some years a definite well planned training setup, headed by the mechanical foreman, has been instituted with very satisfactory results.

However, with the use of lubricating systems, where possible, and with proper training of the indivudual responsible for lubrication of equipment, there are frequent occasions where bearing life has proved unsatisfactory. This was true of the pinion bearings for the blooming mill. For many years a lead base babbitt was used. This type of babbitt proved satisfactory elsewhere from information obtained from other plants. Nevertheless, it was decided to change to a high tin babbitt for these pinion bearings. The thickness of the original babbitt was about 1 in. but when the high tin babbitt was decided upon, its thickness was reduced to ⅜ in. by a redesign of the chocks. This resulted in the relative cost of the babbitt being about the same. At the same time, washed air was introduced into the pinion housing with the result that the bearing life increased from 400,000 tons to over 2,000,000 tons. This change resulted in a respectable saving.

This matter of mill bearings and lubrication is a matter of maintenance and contributes considerably to the success of the mill. As long as there are mills, they will continue to wear out even with the best of materials and with the best of care, requiring therefore certain periods for inspection, repair of worn parts, etc. Some of the bigger and therefore more costly repairs, occur only occasionally. I refer specifically to those that require a considerable shutdown, and therefore, become an important factor in the ultimate cost of maintenance. When these repairs occur once in a period of years, after many years have passed, improvement is made in the length of time required for repair. I am sure, however, that we have all had the experience of having one of these jobs take longer, and of having one of these jobs develop some unforeseen difficulty, due to some younger man not knowing the details of the last change or due to the fact that some detail small, but important, has been forgotten. Therefore, with the above in mind, there has been inaugurated the practice of taking photographs of the setup for a job of this type. Where some particular rigging setup has been required, where platform building is necessary, where some particular part has to be handled in a certain manner, a photograph tucked away in the files has proved to be exceedingly helpful. Few of us, I believe, are anxious to write up and to keep a record in detail of many jobs of this sort. We have found that a photograph takes the place of much detailed record keeping.

All who are concerned with the operation of mill equipment are confronted with the facts of maintenance. Though the individual directly responsible for maintenance of equipment may by his ingenuity, by change in design, and by change of materials improve that equipment, it must be admitted that those operating the equipment have to contribute their share to obtain finally lower maintenance costs.

DISCUSSION

PRESENTED BY

L. A. TERRY, Superintendent, Power and Electrical Department, Tubular Alloy Steel Corporation, Gary, Indiana

F. B. GOLLEY, Assistant Superintendent, Finishing Mills, Wisconsin Steel Works, International Harvester Company, South Chicago, Illinois

L. A. Terry: In applying composition bearings, the author mentioned that he ground the fillers. Do you also grind the roll necks?

F. B. Golley: I think you refer to the statement that it is necessary at times to grind the collar of the bearing. Our scale guard is so designed that it fits over a shoulder and into a groove cut in the thrust face of the roll, therefore, the thrust face area is less than usual. As the roll diameter is reduced, it is necessary to reduce also this scale guard shoulder at least once in the life of the roll. Therefore, using various size rolls we have different contact areas on the collar. When changing from a small size roll to a large size roll, we find it necessary to grind the collar to gain again a proper bearing area. We have not found it necessary to grind the roll necks.

MAINTENANCE OF TEMPERATURE INDICATING AND RECORDING INSTRUMENTS

By HARRY C. MORROW

▲ THE meter and instrument department at the Gary Sheet and Tin Mill is organized as a service and testing unit under the direction of the power and fuel division. Its present personnel consists of a foreman and 29 service men, each of whom possesses various abilities

and qualifications in keeping with his particular functional assignment.

Utilizing the facilities of three separate shops, each specifically developed for a particular phase of the work, this manpower is distributed in the task of maintaining accuracy, continuity of operation, and good physical condition of all metering equipment, associated control mechanisms and electronic units throughout the plant. This is a responsibility involving more than 7000 instrument and control units. Specifically, the work is channelled into four subdivisions, as follows:

1. Electrical meter group — 5 men.
2. Electronic and communication group — 3 men.
3. Flow, pressure and thermal type temperature recorder and controller group — 7 men.
4. Thermo-electric type pyrometers and controllers — 14 men.

Our discussion deals specifically with the equipment in the last section, which assumes proportions of vital import in the final analysis of quality in production control.

Meter control coverage in steel industrial units has made rapid advancement only during the past decade. From a period in which the meter equipment in the average plant consisted solely of such meters and controls as were introduced as component parts of new equipment, and those units traditionally associated with general mill practice, the situation has changed rapidly to the present, in which the meter and instrument department finds its facilities projected into every phase of the production picture.

In the work of this department, we are constantly finding new and highly practical applications for instrumentation and, in many instances, the use of a given type of equipment for one purpose in turn gives rise to several other types of equipment in the solution of a single problem, or results in the application of such a development to other manufacturing conditions.

Numerous quality, yield and production rate problems, with which both supervision and employee personnel have long been familiar, have been solved through the introduction of instrumentation. The chief factor in this is the ability of the instrument to point out the precise location of the difficulties which often are hidden in remote points of the equipment or process under test. It follows that the instrument utilized in detecting the difficulty may not be identical with that finally adopted for correction of the difficulty.

Our shop facilities for the thermo-electric pyrometry section have existed since 1933, and additions to the original equipment have been made as practical applications of the work dictated necessity.

In operation, the servicing and maintenance of all instruments is predicated upon availability of precision checking equipment; therefore, in the shop a type K precision potentiometer with a Bureau of Standards certified standard cell and standard thermo-couples are maintained as the plant standard for all measurements and calibrations.

For secondary standards, we utilize a semi-precision potentiometer and a type PM-1 calibrating set.

As auxiliaries, for both shop and field work, a battery of eleven portable potentiometers of various ranges and thermo-couple types are maintained, in addition to Wheatstone bridges, circuit analyzers, tube testers, voltmeters, ammeters and other testing apparatus.

From the experience gained over a period of years, we have concluded that it is not necessary to maintain a large stock of parts for any one or group of instruments. Auxiliary supplies, however, such as charts, ink, batteries, pens, tubes and ink pads, are maintained in sufficient quantities to insure continuity of all operations.

Major shop activities consist of the rebuilding, repair and servicing of relays, motors, meters and such instrument units as may require recalibrating, range changing, etc., not feasible in the field.

Each shipment of thermo-couple wire received at Gary Sheet and Tin Mill, irrespective of its intended application, is routed directly to the shop for standard accuracy analysis. The tests are made by means of a specially designed thermo-couple-checking furnace, using secondary standard thermo-couples checked with a Bureau of Standards certified platinum thermo-couple. This makes it possible to predetermine the deviation limits of each coil of wire, and thus to match deviation characteristics to assure the desired limits of accuracy of the assembled thermo-couple.

The importance of this precaution may be realized when it is considered that in excess of 1000 thermo-couples, varying from 15 inches to 28 feet in length, the latter used in the sheet mill cover type annealing furnaces, are fabricated, tested and installed in production use monthly in our plant.

As another major responsibility of this shop, the maintenance and calibrating of optical pyrometer units is accomplished with the aid of a check set embodying a 0.001 standard shunt and flat filament lamp, furnished and recalibrated at regular intervals by the United States Steel Corporation Research Laboratory. A system of stated interval checking of all optical units is in operation.

Calibration and adjustment of lens type radiation tubes (also a shop function) is accomplished by sighting the tube upon a block of steel in the thermo-couple checking furnace, and adjusting the lens to a point where the maximum emf registry occurs. The tube is then attached to the instrument in the field and this combination calibrated by means of a standard optical pyrometer.

For low temperature and/or "mirror" type radiation tubes, we imbed a fine wire gage couple in the steel block, approximately 1/64 of an inch from the surface upon which the tube is sighted. The tube calibration is then determined by plotting emf developed versus thermo-couple emf.

There is no necessity for routine service contracts with instrument manufacturers, and the amount of thermo-electric pyrometer equipment returned to them for servicing is very small in comparison to that accomplished in our own shops. In fact, the major portion of all types of equipment returned to the manufacturers are the sealed thermal elements, such as the vapor-tension and mercury or gas-filled systems, requiring special equipment and calibrating apparatus.

We have made no attempt to obtain equipment to service thermal systems as the many proprietary styles and types in use would make this an almost impossible task. Further, the advent of the several electronic type high speed thermo-couple controllers, with the simplified

air control systems, is causing a rapid decline in the use of thermal system instruments.

TYPICAL FIELD INSTALLATION CHECKING

The 80 in. hot strip mill is equipped with three triple-fired slab heating furnaces, originally designed for producer gas fuel. This type of fuel did not permit satisfactory control; therefore, the furnaces as installed were equipped only with combustion air pressure regulators. However, in recent years, natural gas has been provided, making possible the installation of temperature controlling equipment in the soaking zone of each furnace. This equipment is of the radiation type, with a closed end, silicon carbide target tube extending down through the roof approximately 10 inches. When first installed, the tubes proved to be quite a maintenance problem because of the seepage into them of soot, smoke and iron oxide, which in turn clouded the lens of the radiation unit. This condition was easily corrected, however, with the addition of an air-injector nozzle in the head assembly, permitting the build-up of a slight positive pressure in the tube. The control is of the proportioning type, electrical, with motor operators on both the gas valve and air-header butterfly. Results from this control are satisfactory.

For rolling temperature indications there are four high-speed recorders of both the photo-electric and radiation type. One is located at the delivery side of the final roughing stand, one at the holding table between the roughing and finishing mills, one at the delivery side of the final finishing stand, and one at the coiler.

We favor the radiation type units because they require less maintenance and it is much easier to provide artificial ambient temperature control for them than for the photo-electric type units. Their major fault, of course, is the clouding of the lens or window.

With but a few minor exceptions, annealing, in both the sheet and tin divisions, is carried on in the tube or bell type annealing furnaces. Due to the construction of these furnaces, permitting the operator no visual indication of the material in process, and the rigid temperature limits imposed by quality requirements, annealing cover temperature controls are considered the most vital in the plant.

All covers are equipped with six-point recorder-controllers, proportioning relays, valve drive operators and valves. Each installation receives daily checking for accuracy and control action. Valves are lubricated once each month and, if necessary, removed from service and cleaned.

Each operating division maintains a crew of men whose duties are to fabricate thermo-couples and install them in the various furnace charges as required. Thermo-couples are made of 6 gage iron wire and 8 gage constantan wire, protected by single-hole porcelain insulators. In the tin division, work couples may be used for approximately 20 charges, while those in the sheet division are replaced after every heat.

Other divisions in the plant with equipment similar to that already mentioned are the galvanizing shops, the tin house, alloy division, electrolytic tinning, sheet hot mills and 42 in. hot strip mills. Twenty-four-hour-a-day instrument service, seven days per week, is available to any and all of these divisions.

For instrumentation service, the operating divisions are grouped into five sections, with one or two service men in each, depending upon its size, amount of equipment, and control requirements. Daily, the service man first makes a complete inspection of all equipment under his supervision, during which time he replaces charts, ink pens, and standardizes instruments. He also notes items requiring further attention and returns to them upon completion of the inspection, or notifies the instrument foreman who, in turn, assigns the work to the shop men. These men determine whether or not the equipment can be serviced in the field or must be returned to the shop. If the latter is decided upon, they must set up temporary controls in order that process work will not be interrupted. The service man is responsible for the entire control installation, for primary element to the final control valve.

The only actual routine servicing schedule is that of cleaning and lubrication, and this is determined on a departmental basis because of the many and variable atmospheric conditions under which the equipment must operate.

We are rapidly accepting the use of air-operated controllers for many applications. However, we are still of the opinion that there are, and will always be, many steel mill applications for which air control is not suitable, chiefly due to the difficulties encountered in the conditioning of compressed air. Our present air controls operate from the general plant system, but we have eliminated most of the anticipated difficulties by the use of good filter and drip-well combinations that are always installed ahead of the pressure regulators or reducing valves.

Pyrometers embodying the electronic principles are also being installed. Their mechanical simplicity, which naturally alleviates the necessity of much maintenance work, is the chief factor in their favor. However, their usage does require service men of a different caliber than heretofore thought needed for meter and instrument work.

In addition to servicing or maintenance work, the pyrometer group conducts test and research work for the metallurgical and operating departments. In conjunction with the engineering department, the meter and instrument department determines the type of temperature controlling equipment required on new or revamped installations, and either installs or supervises the installation of the equipment when received.

Finally, all of the activities which we have touched upon can be conducted successfully only if certain fundamentals are recognized. These include:

1. The importance of high precision equipment in any control application.
2. The necessity for "engineering" any meter or control installation to the specific conditions of the job.
3. The vital need for absolute adherence to a proven plan for installation and operation.
4. The importance of close liason between operating department personnel and instrument department technicians to develop better understanding of instruments, their importance and benefits.
5. The demonstrated willingness of instrument manufacturers to cooperate in all phases of established

requirements and the development of specific adaptations.

Following these principles, it has been shown that an intelligently planned and properly functioning meter and control system can make increasingly effective contributions to operating efficiency and product quality.

MAINTENANCE OF MAIN DRIVE MOTORS AND MOTOR-GENERATOR SETS

Prepared by Inland Steel Company Electrical Organization

Read by V. E. SCHLOSSBERG

▲ THIS paper is not the product of the speaker. It is a consolidation of several papers by the supervisory men of the electrical department of the Inland Steel Company.

Preventive maintenance of main drive electrical equipment is essential for efficient operation. It will minimize unscheduled shutdowns, commonly called "breakdowns" resulting in:

1. Better customer satisfaction due to improved rolling and shipping schedules.
2. Lower production costs due to more efficient use of labor, power, fuel, steam and water.
3. Lower repair costs due to fewer equipment failures and smaller repair crews.
4. Small inventory of spare parts.
5. Improved morale of operating maintenance crews.

We subdivide our preventive maintenance program into two parts. The first part, which we call "routine maintenance," consists of that portion of maintenance which is done daily, weekly, or at other regular periods. The second part, which we call "planned maintenance," consists of that portion of maintenance which is done on a frequency basis determined by inspection and previous operating experiences.

ROUTINE MAINTENANCE

Routine maintenance covers inspection and maintenance of equipment by the normal operating force during rolling, "down" periods, and repair turns, generally without specific direction by the foreman.

For best results, we have found that the operating force must be trained to be alert, conscientious, thorough, safety-minded, to be able to make quick decisions, and to know their equipment and circuits. Other valuable assets such as, the ability to detect unusual operating conditions, noises, temperatures, etc., are acquired with length of service on the job.

We have also found that the assignment of the maintenance of specified units to each operator works out very well. With this system, each man takes pride in keeping his equipment in first-class condition. There is no duplication of work on any one unit, and each unit receives its share of attention. While the mill is in operation, all equipment receives the necessary routine inspection by the operating force on duty. Due to scheduling of personnel, it is at times impossible for a man to have a weekly repair turn in which to cover his assigned equipment. In such cases, his assigned equipment is taken care of by the man scheduled to replace him during that repair turn.

Routine inspection and maintenance while the mill is in operation includes:

1. Inspection of bearings for temperature, proper functioning of oil rings or oil supply system, water flow and temperature of water-cooled bearings, and checking for oil or water leaks.
2. Inspection of commutators for sparking or glowing of brushes and for chattering of brushes due to improper seating, high bars, or low spots.
3. Inspection of machines for frame temperature and unusual noises or odors.
4. Inspection of circuit breakers and knife switches for overheating.
5. Observation of unit load conditions, including the balancing of loads of paralleled generators.
6. Observation of voltage, current and speed regulators and other control equipment to make sure that they are functioning properly.
7. Checking the various systems for grounds, generally by use of specially provided test panels using lamps or voltmeters.
8. Inspection of the ventilating fans and air filters.
9. Regular maintenance, whenever possible, of units not in operation, including auxiliary equipment.

Routine inspection and maintenance during repair turns covers the systematic cleaning, checking and repairing of electrical equipment by the operating crew assigned to that equipment.

Motors and generators are blown out thoroughly with clean, dry air, taking care that pressure is not high enough to damage the insulation. Brushholder insulators, bus insulators and windings are wiped, and the bands, V-rings and riser connections are inspected. Capacitors and lightning arrestors in motor pits are also inspected and wiped.

Approximately every three months, the end guards are removed from the generators and motors, and a thorough job of cleaning and inspection is done. Field and pole face connections are inspected for signs of being loose or overheating. Band wires and wedges are inspected. The windings are inspected to see that the insulation is not loose or damaged, and insulation tests are made and recorded. Air gaps and brush spacing are checked twice a year, and, if necessary, corrections made.

To return to our weekly maintenance program, brushes are checked for length, freedom in holder, and for frayed or broken shunts. As necessary, new brushes are installed and properly seated.

Commutators are checked for grooving or other unusual wearing, and the commutator slots are cleaned of any carbon, loose mica or copper that may be present.

Bearings are inspected and wiped. If necessary, the oil is brought up to the proper level, and loose seals are replaced.

Air circuit breakers, knife switches and other control devices are inspected and cleaned. Contacts, worn shunts, toggles and pins, are replaced as required. Rheostat face plates are cleaned and lubricated.

Grounds, if any, on the various systems are isolated and cleared.

Air filtering equipment is inspected and wiped. Sludge

is removed from oil tanks, and the oil is brought up to the correct level.

If during such inspection and maintenance periods, the operating crews note any unusual condition which they themselves cannot correct immediately, they notify their foreman. The foreman arranges to have the necessary repairs made immediately, if required, or to have the repairs made at an early date.

PLANNED MAINTENANCE

Planned maintenance covers the periodic inspection and repair or overhaul of equipment, the frequency of which is based on past records, operating conditions since the previous repair, and the condition of the equipment as revealed by prior inspections.

The yearly clean-and-varnish schedule for all main drives and supporting motor-generator sets is sent to every electrical foreman and mill superintendent during the first week of January. This is our yearly starter to a definite, planned program of preventive maintenance.

Dependent upon operating conditions, our main drive motors and generators are disassembled, cleaned and varnished, on the average, of once every three years. This may be reduced to once a year in some localities where dirt conditions are extremely bad, or where palm oil or other oil vapors are drawn into the machine and deposited on the windings. It may be extended to four or five years where conditions are favorable.

Before disassembling, care is taken to have match marks on couplings, frames, brush yokes, and other parts to aid in reassembly and to be assured that frame, stator, brush position, etc., will not be shifted. Precaution is also taken against leaving foreign matter in the machine by checking the number of bolts, cleaning brushes, tools, etc., before the work is started and after it is completed. Also before disassembly, the insulation resistance is measured for future reference.

To assure thorough cleaning and varnishing, disassembling is carried to the point which will permit complete accessibility of the rotor and stator. On a-c units, the stator is generally shifted on the base. On d-c machines having split frames, the top half of the frame is taken off and the armature is removed. Where the above procedures cannot be followed, the complete machine is taken off of the base and the rotor then removed.

Cleaning is accomplished by blowing with dry compressed air and by using scrub and bottle brushes of various sizes. If the windings have an oil deposit, it is necessary to use cleaning solvents. Some of these solvents are inflammable, and others are toxic. Such solvents, therefore, must be used with extreme care, guarding against fire and overexposure of fumes to the users. Cleaning is continued until a satisfactory insulation reading is obtained, or the cause of the low reading is determined and cleared.

We have also done some cleaning of oily windings by using finely pulverized corn-cobs in a portable blasting machine. This method is very effective in removing oil, but great care must be taken so as not to damage the insulation by too much blasting.

Before varnishing the unit, bands, wedges, bonnets, stringing, connections, and insulation are carefully checked. If necessary, experienced shop men are brought in to perform any special work that may be required. In our experience, we have had to replace or secure bands, tighten wedges, resolder connections, and reinsulate leads.

The unit is then varnished, applying one or two coats of air-dry varnish with spray guns. This air-dry varnish is very beneficial in that it seals cracks in the insulation due to drying and shrinkage, and it also assists in holding the insulation supports and wedges in place. It has been found that two light coats, with sufficient drying time between applications, is preferable to one heavy coat. In very oily locations, the second coat applied is an oil-resistant glyptal.

During varnishing, extreme precautions are taken against fire. The area is roped off, and "No Smoking" signs are placed in prominent positions. Vapor-proof extension lights are used. Varnish guns are grounded to prevent static sparks. Fire-fighting equipment is tested and positioned ready for use.

Advantage is taken of these cleaning and varnishing periods to carefully inspect the bearings, particularly the bottom linings which are seldom removed during normal bearing inspections. Insulated bearings are tested for insulation failure, and the insulators are changed, if necessary. Couplings, keys and keyways are also inspected at this time.

After reassembly, the insulation resistance is again measured. The number of bolts, cleaning brushes, and other tools is again checked to make certain none are remaining in the machine. A record of the work done is made for future reference. This record includes the insulation level readings and air gap measurements, the time and number of men required, the procedure followed, and a list of the special tools, slings, etc., required.

Other examples of planned maintenance, which are included in our program are as follows:

Samples of oil from transformers and oil circuit breakers are tested periodically. These tests are conducted in accordance with ASTM standards. Oil which fails to pass these tests is centrifuged until satisfactory tests are obtained.

Oil circuit breakers are dismantled and inspected, and the necessary repairs are made.

Liquid slip regulators are inspected, and the necessary repairs are made. This includes the moving and stationary electrodes and other current carrying parts. The cooling coils are cleaned and flushed, and any sludge accumulation is removed from the bottom of the tank.

Rotor and field collector rings are ground as required. This is done by using a lathe type stone holder, rigidly supported.

Commutators of motors and generators are ground and undercut when considered necessary. Before starting the grinding operation, it is important that the mica is sufficiently undercut to insure that spots of flush mica will not cause the commutator to be ground out of round, and also to facilitate the final undercutting. While grinding, the ventilating fans are kept running, adjacent machines are completely covered, and the operators are required to wear goggles and respirators. The grinding speed is kept at as near normal operating speed as possible.

When grinding generator commutators, all brushes are raised off the commutator. When grinding motor commutators, only enough brushes are left on the commutator to insure good commutation, and the voltage is kept low enough to prevent flashover due to copper grindings.

Most of the grinding is done with a medium-coarse stone, and the commutator is finished with a very fine-grained polishing stone. Hand stones are used on light grinding jobs and on large diameter commutators which are not out of round. Lathe type stone holders, rigidly supported to prevent chattering, are used on commutators which are out of round and on high-speed small diameter commutators so as not to grind such commutators out of round.

Commutators are generally undercut with a motor-driven mica undercutter having a long flexible shaft and using "U" type saws. We have saws of various widths, and we are careful to use saws of the correct width so as to remove all feather and side mica and still not cut the bar. A narrow piece of fiber is wrapped over the V-ring to protect it. The commutator slots are then bevelled by using a hand tool with a ¼ in. square lathe tool which is properly V'd.

After the grinding, undercutting and bevelling are completed, the machine is thoroughly cleaned to remove all traces of copper grindings.

Main drive bearings are inspected at least once in two years, or more frequently if deemed necessary. Bearing caps, top linings, and oil rings are removed. The old oil is drained, and the oil well is cleaned. The bottom linings are not removed unless inspection indicates they need attention. The shaft is inspected for rough spots and for signs of electrolysis. Rings are roughened up to carry more oil, and the wipers are inspected. The bearings are then reassembled, and new oil is put in. The old oil, incidentally, is saved for use in our oil-impingement type air filters.

Our protective devices also come in for their share of attention. Overload, undervoltage, overvoltage, field loss, current-limit and voltage-limit relays are periodically tested to insure that they actually work. Overspeed device and air circuit breaker tripping values are also set by actual tests.

Essential to good maintenance is a good and complete set of tools and other equipment to work with. These include portable instruments, tachometers, commutator grinders, mica undercutters, bevelling tools, gasoline torches, stoves, socket wrenches, open-end wrenches, eye-bolts, sledges, portable stand lamps, varnish guns, etc. Good lifting beams and special cables for individual units are also invaluable for fast disassembly and assembly.

Another valuable asset for good maintenance is a set of complete and accurate records covering each major unit. Such records should show the past performance, normal insulation level and air gap measurements, time and tonnages between previous repairs, the nature of previous repairs, the length of time and number of men required to do the work, the procedure followed, and a list of slings, wrenches and other tools and material required.

In closing, we would like to point out that one of our most important preventive maintenance aids is our management. We are, indeed fortunate in having a management which recognizes the value of preventive maintenance, which has allowed us to obtain the necessary tools, supplies, spares and test equipment, and which has been most cooperative in arranging operating schedules so that this work can be carried on in a systematic manner.

DISCUSSION

PRESENTED BY

A. R. DIBBEN, Assistant Electrical Superintendent, Youngstown Sheet and Tube Company, Indiana Harbor Works, East Chicago, Indiana

V. E. SCHLOSSBERG, Superintendent Electric, Power and Steam Department, Inland Steel Company, East Chicago, Indiana

A. R. Dibben: I would like to ask Mr. Schlossberg what method they use for instructing their personnel, and also how often they use the air-dry varnish to take care of their motors and generators.

V. E. Schlossberg: This paper which I presented was prepared by the electrical organization who instruct our personnel. We have a set of instructions prepared by the electrical organization for the specific job. That generally consists of half a dozen men that are completely familiar with that type of work. These written instructions are then sent out to each electrical foreman so he can review them thoroughly before doing a job of that type. As far as instructing the actual operators, we go back to the old time system, which we have found to be the best and that is direct contact with their immediate superior or their foreman.

On the second question, air-dry varnish is used on all roll train units.

A. R. Dibben: How often is the air-dry varnish applied?

V. E. Schlossberg: You will notice that we set our schedule once every three years. On some units, like the cold mill units, everyone knows the condition we have there. We do them once every year. Some units like a billet mill is done once in five years. Timing is all based on previous experience with the particular mill.

Member: I would like to ask Mr. Schlossberg what their practice is in regard to cleaning materials from the standpoint of toxic effect or permeability characteristics.

V. E. Schlossberg: That depends on the cleaning solvent you use. If you use carbon tetrachloride, you have to be careful to use it in a well-ventilated room, and you will have to provide respirators and air masks for the men using it. If you use gasoline, you have the fire hazard to guard against. If you use some of the commercial solvents, you have the residue which might get into small places and cause trouble. We have found in our plant the best thing to use has been a mixture of 50 per cent gasoline and 50 per cent carbon tetrachloride. That does not give a fireproof solution but it has given us the best results.

THE Y-MILL...

A NEW TYPE OF COLD STRIP MILL

.... the Y-mill is a unique, reversing cold mill which offers possibilities for economy of operation and quality of product rolled ....

by

A. B. MONTGOMERY, Consulting Engineer

Pittsburgh, Pennsylvania

and

W. M. McCONNELL, Chief Engineer*

Mackintosh-Hemphill Company

Pittsburgh, Pennsylvania

▲ FOR many years, designers of rolling mills for sheets and strip have sought to build a cold reducing mill that would make a close approach to correct and uniform gage, and, also, transmit sufficient power to the work rolls to make substantial reductions at highest practical speeds.

During the period of the two-high sheet mill, when the physical design of the mill and roll neck bearings required large sturdy necks, the quest for accuracy of gage was directed toward the provision of rolls which had a surface profile suitable for the most accurate rolling feasible under normal working conditions. These normal conditions arise mainly as a result of temperature variations along the rolls, and the deflection of the rolls themselves under load, hence, the process soon reached its own standards of gage that could not be improved beyond certain limits. The rolling efficiency, speeds, and tonnages of these mills were necessarily very low.

The rolling mill manufacturer, and the rolling mill engineer, in seeking to improve overall efficiency and accuracy, developed the three-high, four-high and six-high mills. With the advent of anti-friction bearings, these mills and the two-high mill have been brought close to the limits imposed on their efficiencies and speeds by work roll diameters and roll neck bearings. Correct and uniform gage of strip on these types of mills is now limited to the profile of the roll body and rigidity of the mill, such as stretch in the housings, deflection of the rolls, etc.

It has been repeatedly pointed out, by many authorities and designers of rolling mills, that the smaller the work roll diameter, the more accurate and efficient the rolling process becomes. To gain a maximum of these results, the roll diameters for various rolling schedules and materials, should be selected as small as the required gripping capacity of the rolls will permit. However, this ultimate may not be practical if speed and tonnage are desirable. The more uniform thickness of the rolled material over its width and length is the result of the reduction in roll flattening, at the pressure point with decreasing roll diameter. The ratio of the thickness of the strip on the delivery side of the mill, to the work roll diameter, determines the deformation efficiency, hence, efficiency increases with decreasing roll diameter. The deformation efficiency reflects itself in the fact that small diameter work rolls can make greater overall reductions without intermediate annealing.

The relation of the roll diameter to compressive resistance, forward slip and spread is fairly uniform, according to the studies of Leug and Pomp. With larger roll diameters of 7 in. and greater, compressive resistance (roll pressure divided by the area of the compressed strip) increases rapidly up to 10 per cent reduction and is still rising, even with heavy reductions up to 60 per cent, although the rise is less rapid. On small roll diameters, say 3 in. and under, the compressive resistance is much lower, and passes through a maximum at 20 to 30 per cent reduction. The forward slip with the large diameter rolls, increases more or less regularly from zero with rising per cent of reduction.

In a three-high arrangement of rolls, using a 7 in.

Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 22, 1947

* Now Vice President in charge of Engineering, Taylor-Wilson Manufacturing Company, McKees Rocks, Pennsylvania.

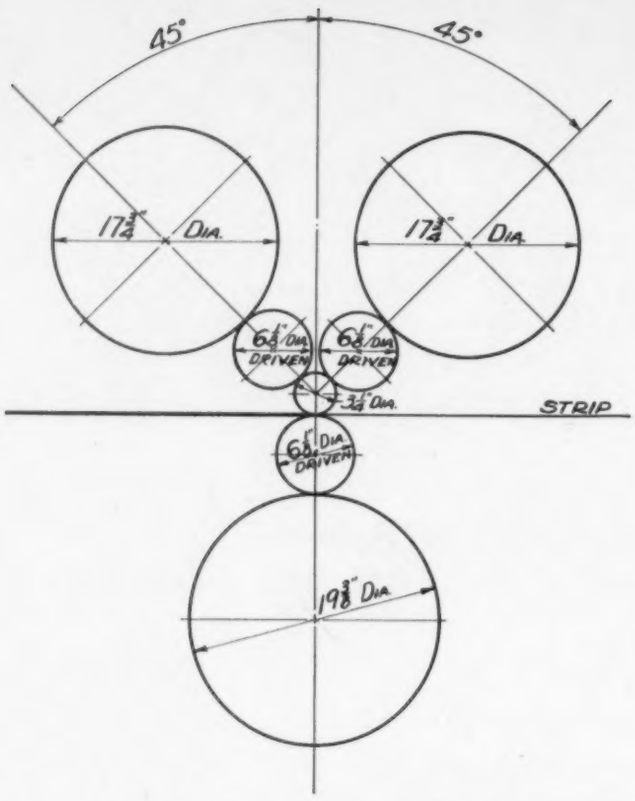


Figure 1 — Sketch shows roll layout for a 20 in. reversing cold mill. It can be easily seen why the mill is called a Y-mill.

and 2⅜ in. roll, having an equivalent diameter of 3⅝ in., the forward slip is negative, in most cases at reductions exceeding 20 per cent. When using two small rolls, say 3 in. and under, the forward slip passes, through a maximum, at reductions varying from 6 to 20 per cent. After passing through this maximum, the forward slip drops to zero at between 30 and 60 per cent reduction. The values of forward slip with the 3 in. and under rolls of equal diameter are below 2 per cent and never exceed 3 per cent. For the 7 in. diameter roll, the maximum values of forward slip are in the region of 8 per cent. The general accepted theory is that the forward slip, for any group of rolls, reaches a maximum value when the roll angle is equal to the bite angle. The per cent of forward slip on larger work rolls than 7 in. will be correspondingly greater. When using any tension, no matter how small, we can practically ignore the forward slip on the above three-high rolls. The spread in the strip when using small rolls increases with increase in per cent reduction, at first slowly, and then more rapidly; above 50 per cent there is practically no increase. Increasing roll diameters cause a rapid rise in the spread, with 7 in. diameter and larger rolls showing still increasing spread at 50 to 60 per cent reduction. The reason for the greater spread is the increase in the compressed length of metal along the lengthwise direction of strip with the rise in roll diameters, which causes an increase in the resistance to flow in the direction of rolling and, consequently, an increased flow of material in the transverse direction. The larger elongating effect of the small rolls is thus shown by the opposite effects they product. These factors also reflect themselves in the accuracy of gage and greater overall reductions possible with small diameter work rolls.

Studies in the relationship between roll pressure and roll diameters by Leug and Pomp, show that rolling efficiency generally rises when the heaviest reduction possible is taken on the smallest diameter of work rolls feasible. In rolling practice this is not usually obtained because better surface and fewer roll changes require slightly larger diameter rolls. An average efficiency of rolling of 70 per cent is obtained for all reductions from 5 to 50 per cent, when using approximately 3 in. work rolls. This average efficiency drops off to 50 per cent on 7 in. diameter rolls, 40 per cent on 10 in. diameter rolls, and, proportionately on still larger rolls.

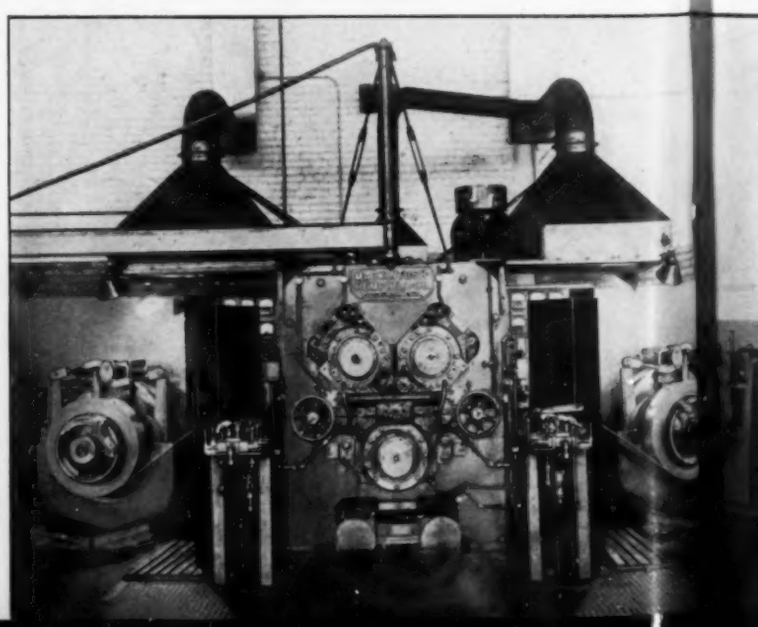
Y-MILL

The compact arrangement of the mill results in the most rigid type of housing construction. Due to the fact that the housing windows are very short and the roll pressure light, there is practically no stretch in the housing when taking maximum reductions. The fundamental design of the cluster part of the mill is to provide means for maintaining an approximate 90 degree angle from the center of the small friction driven baby or top work roll, through the axes of the intermediate back-up or driven rolls and the large main top back-up rolls. This arrangement is maintained by shims under the top back-up roll chocks, the shims being used to compensate for roll grinding and for maintaining correct alinement of the top roll assembly. The required thickness of shims is read directly from a gage that measures the distance between the top intermediate back-up rolls, in relation to their diameter and that of the baby roll. The 90 degree angle between the rolls in this part of the mill is essential to good operations. The set-up of the upper group of rolls is easily obtained and can be held to a variation of 0.0005 in. from end to end of the rolls.

The rolls in the mill are arranged in the form of the letter "Y," as shown in Figures 1 and 2.

Beneath the strip, a 6¼ in. maximum diameter work roll is supported along its body length by a 19½ in. diameter back-up roll. These two lower rolls are carried

Figure 2 — The compact arrangement of the Y-mill is shown in this front view of the mill stand and coilers.



on housing screws, and may be adjusted up or down in the housing to suit strip thickness.

Above the strip, and directly over the lower work roll, is a V-shaped group of five rolls. The bottom roll in this formation is a 3¼ in. maximum diameter baby work roll. Contacting this small roll on each side, at 45 degrees from the vertical and forming the legs of the V, are two intermediate 6¼ in. diameter rolls, each of which is supported by its own 17¾ in. diameter back-up roll.

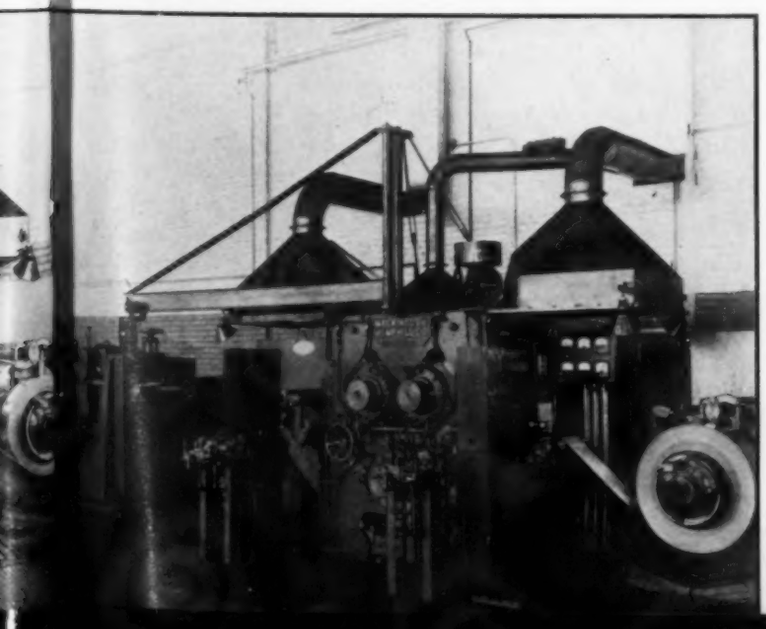
Each upper back-up roll is clamped in place at the top of its housing window, with a self-alining rocker plate, to provide protection for the roll neck bearings against roll deflection. The two upper intermediate rolls and baby roll are balanced by springs or hydraulic cylinders, mounted in the lower work roll chocks, to maintain roll contact between all the rolls, when idling the mill.

The 8¼ in. diameter lower work roll, and the two 6¼ in. diameter upper intermediate rolls, are driven through spindles from the mill pinion stand. The diameters of the three driven rolls are matched to the normal variation in diameter allowable in four-high mills. The baby work roll and the back-up rolls are not driven. The mill can be arranged with the driven rolls from 5¾ to 7¼ in., and the baby roll from 2⅝ to 4 in.

The lower work roll and the back-up roll are adjusted up and down on non-rotating housing screws, mounted in the lower part of the housing windows. All screwdown parts are designed so that the rolls may be forced into the strip. A single 5 hp motor with reduction gears furnishes power through gear type mechanical clutch to each screw. Clutches are pushbutton operated. Mechanically driven dial type roll opening indicators are mounted on the mill housing. This screw assembly has a 2000 to 1 ratio, and gives accurate pressure adjustment to the mill to control the gage of the strip.

The coilers are mechanically collapsed or expanded by a new method which is extremely simple and rigid. When expanded, the reels grip the strip for rotation in either direction. The motors driving the reels produce either pull or drag by acting alternately as motors or generators. Sufficient tension is produced by the reel drives so that the strip will be rolled flat and tight on the coil.

Figure 3 — This view shows the coiling equipment on the right end of the mill.



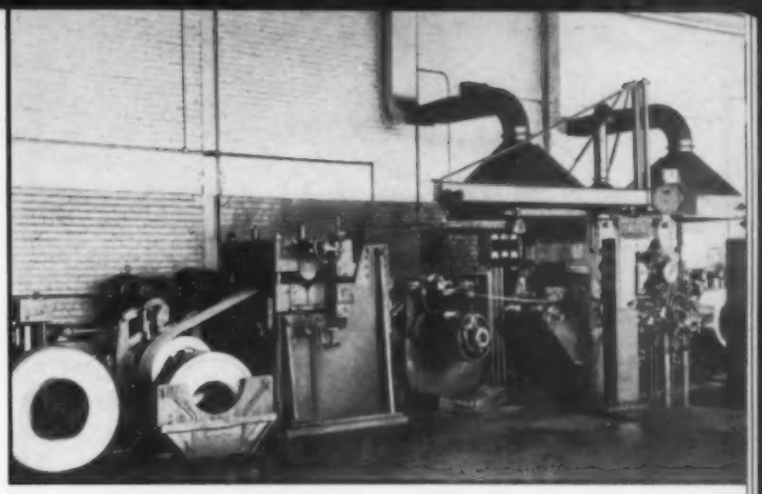


Figure 4 — This figure shows the opposite end of the mill from that shown in Figure 3.

The mechanical operation of the mill, in regard to gage control, speed, loading, guides, coiling reels, etc., is identical with the best mill practice.

MILL OPERATION

The sequence of operations of the mill are as follows:

The hot rolled coil is fed from the payoff reel through a threader leveler over the top of the left reversing reel on the first pass, and through the mill to the right reel. On the second pass, the strip is fed back into the left reel. All succeeding passes are made by reversing the mill and reels until the strip has been reduced as much as practical before annealing for a second series of passes, if this is required.

When cold reducing strip, the rolls are adequately lubricated by a flood of filtered soluble oil coolant or lubricant, thus keeping the mill at a constant temperature which holds the contour or shape of the rolls. The coolant oil also protects the surface of the rolls, and reduces the roll friction.

DESIGN FEATURES

The mill screw assembly consists of non-rotating bronze screws, which raise and lower by means of a rotating steel nut mounted on roller bearings for both the radial and thrust loads. The screws may be driven together or separately by means of a motor, reduction gear, gear type mechanical clutches, and worm wheels mounted on the rotating nuts. The screw, nut, and worm assembly for both screws is built as a single unit with oil tight case, and lubricated by oil continuously from the oil circulation system. The clutches are operated by air cylinders by means of magnetic controlled air valves. The bottom back-up roll chocks rest on a bridge extending between the front and back screw. Spherical washers are placed between the top of the screw and the bridge to insure full bearing on the top of the screws.

The top back-up roll chocks are supported by means of a bridgelike assembly from ears or lugs at the top of the chock. The top bridge is supported in the mill separators by a single hinge bolt on the center line of

the mill, which holds the front and back chocks tightly against the self-alineing rocker blocks. The two top roll chocks are forced against the hardened plates on the 90 degree sloping sides of the housing, by means of a self-alining 90 degree wedge in the upper part of each housing between the rolls. To take care of various diameters of back-up and work rolls, provision is made in the rocker plate assembly for liners which facilitate holding the center line of each group of rolls in the V top half of the Y, at approximately 90 degrees. This 90 degree feature, plus the elimination of the top roll adjustment for gage, gives the cluster mill assembly the same stability and rigidity as the lower set of rolls.

The back-up rolls are mounted on tapered anti-friction roll neck bearing chocks, the lower work roll and intermediate driven rolls are mounted in chocks which contain straight roller bearings. The baby roll is mounted in babbitt lined bronze sleeves with roller thrust bearings. Quick operating locks and clamps are provided to facilitate roll changing. Thrust from the baby roll is taken on removable bridges mounted in the housings by means of quick operating locks. The proper clearance for the baby roll thrust bearings is provided in the dimensions of the roll assembly and chocks eliminating all adjustments. Grease lubrication is used on the baby roll and driven roll bearings, while circulating oil is used on the back-up roll neck bearings.

The mill guides are light and readily accessible with adjustments for all movements provided by handwheels or wrenches.

The mill drive consists of the three driven roll pinions and two idler gears. The motor is directly connected to the lower work roll pinion by means of a flexible coupling. This pinion is connected to the lower work roll by a universal spindle. The top intermediate roll pinions are driven by means of the idler gears. The two top pinions of the drive are connected to the intermediate rolls by universal spindles. All pinions are steel forgings with double helical machine cut teeth and mounted on tapered roller bearings. The drive gears and bearings are lubricated continuously from the central oil lubrication system.

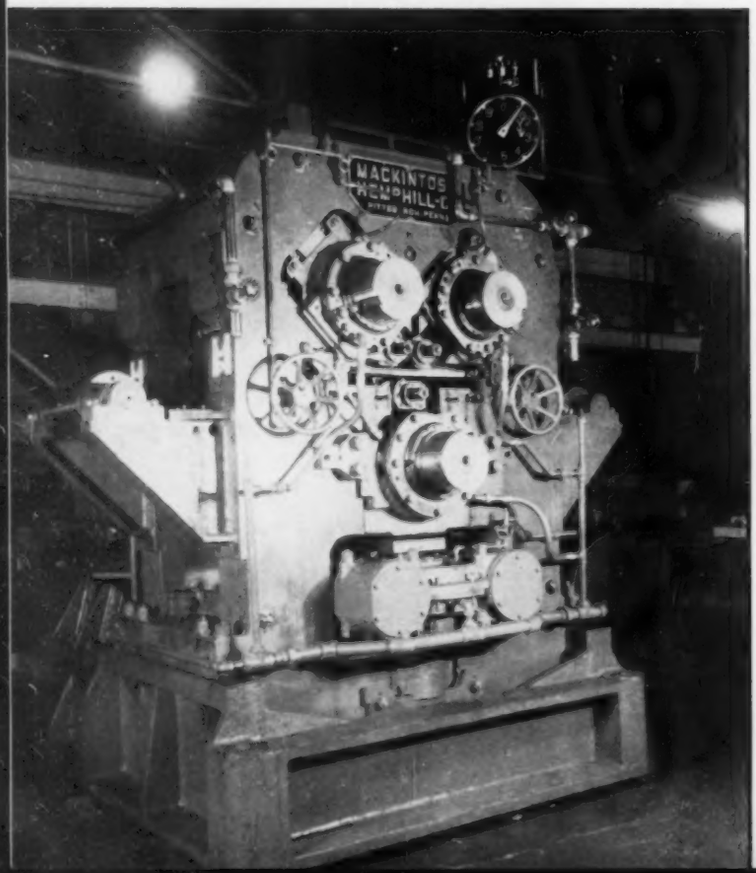


Figure 5 — This view of the mill was taken in the shop before installation and shows the section which is normally below the floor level.

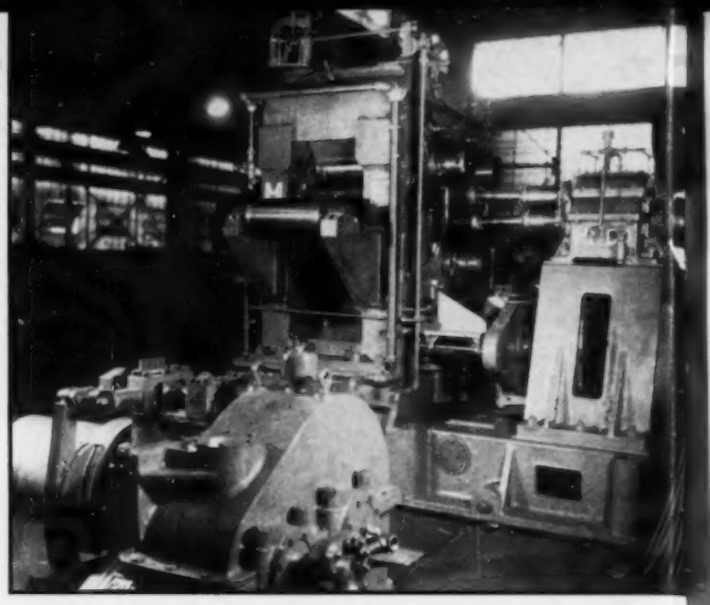


Figure 6 — A 600 hp mill motor is direct connected to the three 6¼ in. diameter rolls.

The coolant system consists of two pumps, strainer, a 3000 gallon storage tank, and will circulate 100 gpm, which is more than ample to dissipate the heat generated in rolling.

The oil lubrication system for the back-up roll bearings, screwdown, and pinion stand consists of a self-contained system having a 350 gallon receiving tank, pumps and all auxiliaries.

Other features in the mill, such as deflector roll, oil seals, roll neck bearing design, roll changing rigs, etc., are similar to conventional mill practice.

ELECTRICAL EQUIPMENT

The electrical equipment for the 20 in. reversing strip mill is designed to roll maximum strip of 17 in. wide, the delivery speed is approximately 600/1200 fpm, and the coil build-up is 22 to 54 in.

The 600 hp mill motor is direct connected to three 6¼ in. diameter rolls.

The mill and 200 hp reel drives are controlled by a variable voltage control system to provide continuous speed adjustment from the low threading speed to any desired running speed. Speeds below 1200 fpm are obtained by generator voltage control, and speeds from 600 to 1200 fpm are obtained by shunt field control of the main mill motor, and variable voltage control of the reel drive motors. The mill motor develops constant torque from 0 to 600 fpm and constant hp between 600 and 1200 fpm.

Individual generators are connected to the armature circuits of the unwinding reel generator and the winding reel motor. The proper basic speed relation between the mill and reels is obtained by rotating regulators operated from a tachometer generator on the mill drive motor,

and varying the voltage of the reel generators directly as the mill drive motor speed, thus requiring shunt field control only to take care of coil build-up, roll diameter and operating variations.

Rotating, constant current, regulating exciters, are used to control the generators to maintain approximately constant reel tensions during the unwinding and rewinding of each pass. The control provides for automatic recalibration of the regulators during acceleration and deceleration to compensate for reel inertia, thereby maintaining the same tension as during normal rolling at constant speed.

After completion of the first pass, the direction of rolling is reversed by reversing the generator voltage. The voltage applied to all machines is reversed, and, therefore, their direction of rotation. The winding reel now becomes the unwinding reel.

The power on the 20 in. mill can be increased to 700 or 800 hp on the mill, and 250 to 300 hp on the reels. The present 20 in. mill can be operated to pull 900 hp on the mill and has pulled as high as 1100 hp in certain tests.

MILL DESIGN

The mill, as described in this paper, employs small diameter work rolls, by application of the three-high principle. The nominal 6 in. diameter driven rolls and 3 in. diameter baby roll, as used in this mill, gives an equivalent work roll diameter of 4 in., obtained from the formula:

$$\text{Equivalent work roll } \frac{R}{E} = \frac{2\ (R_1)\ (R_2)}{R_1 + R_2}$$

With minimum rolls in the mill, this equivalent roll becomes 3½ in. in diameter. If we arbitrarily compare the separating force, or rolling load for the equivalent 4 in. roll with a 10 in. roll, we find that, based on the assumption that a 16 in. roll requires an average of 85,000 lb per inch of width, the 10 in. roll will require 67,000 lb per inch of width, and the 4 in. roll 42,500 lb per inch of width. The mill, however, was designed for an average total separating force of 720,000 lb, which allows for rolling of full 17 in. wide strip at 42,500 lb per inch of width, or 60,000 lb per inch of width on an average of 12 in. wide strip. Converting the 60,000 lb figure to the equivalent 16 in. roll basis, gives 120,000 lb per inch of width that is the accepted practice in designing mills for high carbon and stainless steels. All of the loads are based on comparison, which is the ratio of square root of the diameters of the rolls. The relatively lower separating force created by the 4 in. work roll, coupled with the arrangement of the rolls and inherent design of the housings in the mill, makes possible a cold mill, having practically no stretch. A comparison with the heavy four-high mills rolling stainless shows the mill to have not over 20 per cent of the stretch normally found in the four-high mills. The three-high principle gives greater rigidity to the six inch bottom work roll because the rolling forces created by the equivalent four-inch work roll are backed up against strip or sidewise deflection by the six inch top intermediate driven rolls above the strip. While the six-inch bottom work roll is more than five times as strong against sidewise deflection for the same width, when compared to a four-inch unsupported roll, that creates the rolling forces that cause this deflection.

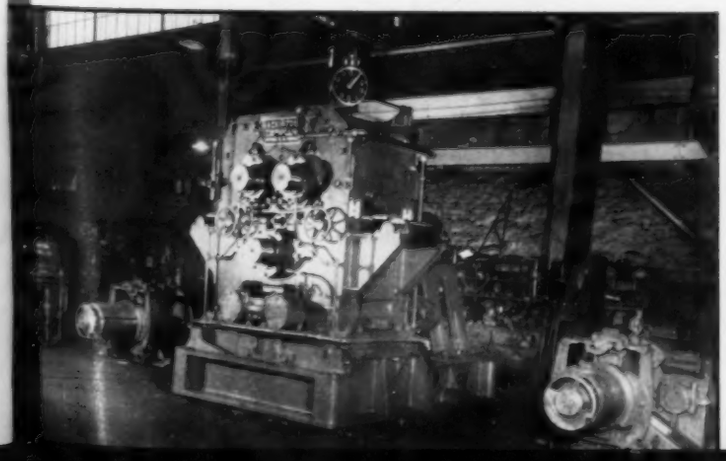


Figure 7 — The proper speed relation between the mill and reels is obtained by rotating regulators.

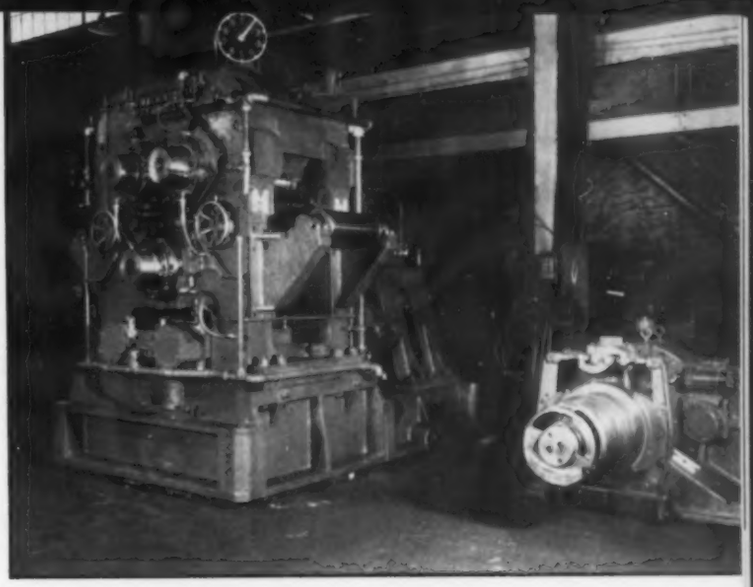


Figure 8 — Delivery speed on the mill is 600/1200 fpm.

The allowable stresses used in the design of the housings are comparable to four-high mill practice for equivalent applications. The same relative comparisons were used in the selection of the back-up roll neck bearings. The bottom back-up roll diameter and bearings are larger than the top back-up rolls, because the sum of the loads on these rolls must be multiplied by the factor 0.707 and added to balance the vertical rolling load on the mill.

The same principles of design can be applied to wider mills with the proportional advantages of accuracy and reductions when compared to equivalent mills using the four-high or six-high principle. The relative diameter of the driven rolls and baby roll used will depend on power, speed and tonnage required of the particular mill being designed.

SUMMARY

The three-high principle as applied in the Y mill gives to the mill all of the advantages of the small work roll up to the point of diminishing returns. In other words, the mill combines the advantages of accurate gage control, most satisfactory rolling of very thin strip along with heavier gages, greater over-all reductions, lower tension, higher deformation efficiency, reduced

forward slip and spread, and lower roll pressures, with production equivalent to conventional mills with large diameter work rolls and equal power at rolling speeds up to 1200 fpm.

The finish obtained on the strip is comparable to that obtained by similar practice on four-high, or other mills not employing the very small or very large work rolls. Roll changes are made in proportion to the kind of steel, total reductions, and tonnages being rolled.

The mill has shown itself to be applicable to both high and low carbon steels and stainless steel for cold reduction and temper rolling.

The 20 in. mill has been in operation fifteen months. Like all new developments, the application of this mill to rolling problems must be by the joint effort of the rolling mill engineers and the designer and builders.

DISCUSSION

PRESENTED BY

A. G. ERICSON, Chief Engineer, Carnegie-Illinois Steel Corporation, Munhall, Pennsylvania

A. B. MONTGOMERY, Consulting Engineer, Pittsburgh, Pennsylvania

W. TRINKS, Associated Engineers, Farmers Bank Building, Pittsburgh, Pennsylvania

A. G. Ericson: I think we have seen here a unique application of the 3-high principle. I was wondering how the heat is dissipated from the baby roll. Being of small diameter and with the speed reductions you are taking, I imagine that the cooling problem might be considerable because of its location.

A. B. Montgomery: In regard to the cooling, the baby roll is cooled by spraying water directly down from the top of the mill, which allows the baby roll actually to run in water between the two intermediate back-up rolls. In addition to that, sprays are spraying on the 3 in. roll from both sides during the rolling operation. I think we have a better opportunity of removing the heat from the small roll than you would have in the larger diameter rolls.

W. Trinks: I would like you to tell me whether the bottom half of the mill is a Steckel mill, and top half is a Rohn mill.

A. B. Montgomery: Professor Trinks, I believe you are somewhat wrong when you classify the top part of it as a Rohn mill. It is true that the bottom half of the mill is the lower half of a 4-high mill, but the Rohn mill does not maintain direct axis through two back-up rolls, and that is where we gain our real mill support.

W. Trinks: From Mr. Montgomery's reply, it is evident that the upper baby roll is driven through the intermediate backing rolls. I have consistently advocated the driving of four-high mills through the backing rolls. In 1935, I saw in Germany a cold-reducing, four-high mill which was driven through the backing rolls and which worked very well.

A. G. Ericson: How often do you have to change the baby roll? The roll must be subject to terrific wear. It would also be interesting to know the material or the hardness of that baby roll.

A. B. Montgomery: The wear on the 3 in. roll does not seem to be any greater than if it were a larger diameter roll. In other words, there is less slippage on the surface of the roll because it is a small diameter. It does not wear any faster than the 6 in. roll that is on the bottom. We have found that in the operation of the mill.

As to the question of how often you change rolls, it all depends on the surface that you are really trying to put on the strip. So far as the wear causing roll changes, the latter is not necessarily caused by wear. It is just due to marking of the rolls, which means the surface required will determine the number of roll changes.

USE OF GRAPHITE AS A SUBSTITUTE FOR PIG IRON

By R. J. MEYERS

Carnegie-Illinois Steel Corporation

▲ AT various times during the last five years the charges used in the acid open hearth furnaces have been examined in an effort to find a charge which would produce satisfactory results at the lowest possible cost. On several occasions, graphite was substituted for pig iron and the amount of high silicon scrap was increased to compensate for the lower silicon content of the charge. It was found that this practice increased the average time required to make a 20-ton heat by at least one hour.

An analysis of recent figures indicates that approximately 7 per cent per ton of metallic charge can be saved by substituting graphite or coke for most of the pig iron in the standard charge. However, this savings does not take into consideration the increased time, the amount of rejections in the cleaning room, and the higher cost of oil and refractories.

The objectionable features of the graphite and silicon slab substitution were weighed against the lower cost of this type of charge, and it was believed that the standard pug charge was more desirable in spite of the difference of about 7 per cent in cost per ton of charge. Consequently, as soon as it became possible to secure pig iron, the graphite and slab substitution was abandoned.

Condensation of paper presented before open hearth division of the American Institute of Mining and Metallurgical Engineers, Philadelphia, Pennsylvania, November 7, 1947.

MANUFACTURE OF MILL TYPE MOTORS

. . . . the inherent thermal capacity of the new motor is at least equal, and in some cases greater, than the old line, rating for rating . . . .

By C. B. HATHAWAY, Manager
D-c Motor Engineering Division
Westinghouse Electric Corporation
Buffalo, New York

▲ THE mill type motor has attained its permanent position for auxiliary drives in steel mills by virtue of its high torque, rugged frame, heavy shaft and sturdy armature. The new line presents another step in the steady progress in the history of this machine. The new line is being developed with the ratings reduced one frame size. There is no change in the mounting dimensions or shaft extension for a given frame number.

The higher ratings are achieved by designing a larger and more efficient armature that fits within the limiting dimensions. To obtain space for greater length, the semi-self contained solid roller bearing is utilized. Not only is the bearing itself shorter but due to its ability to take end thrust, the necessity of the rotating steel collar on the shaft and the bronze thrust collar in the bearing housing are eliminated. Thus the new bearing housing is much shorter and more economical of space than the old.

The greater diameter of the new armature is attained by making an improved arrangement of the field space. The old design had four main and two commutating field coils. This left two large unused spaces, one at the top and one at the bottom of the motor. By using four commutating poles, not only is there a better distribution of the field coils but the fact that each commutating coil requires less turns more space for the main field coils is made available.

The armature coils have a very marked improvement in them. The insulation on the bare conductor whether it be strap or ribbon will be impregnated in silicone varnish. The use of this varnish at this point brings into play material with the highest known resistance to deterioration by heat. Since it is the conductor that carries the load on the armature, it is the prime source of heat generation and therefore, attains the highest temperature, particularly in the portions buried at the bottom of the slots.

We feel that applying the silicone varnish right up against the hottest part of the armature represents a distinct advance in the design of armature coils. The silicone is in the spot where it will do the most good.

The new armature will incorporate a number of improvements over the old. Instead of holding the coils in the slot with bands on the core they are held with wedges made of Class B material. This permits easier winding since each slot can be finally closed up as soon as the top half of the coil is placed in position, and have less pounding and abuse of the coils, than in the case of the banded job. The wedges are designed to give the armature just as high a maximum safe speed as if bands were used. Furthermore, the use of wedges reduces the loss in the armature and increases the efficiency.

The commutator is of the bolted construction and has a fit directly on the shaft. The mica V-rings will extend around the corners of the bars on the inner diameter, which point is vulnerable to grounds.

The core punchings are securely held by rivets between end plates, and are bored to an accurate diameter for a fit directly on the shaft. This arrangement eliminates one fit between the punchings and the shaft and makes a more sturdy construction.

The shaft is made of axle steel and is large for the rating. The key ways in the tapered shaft extensions are of the sled runner type to reduce the possibility of cracks starting in the bottom of the keyway. The shaft is readily removable from the armature by pressing on the commutator end.

Liberal wearing depth has been provided in the section of the commutator bars, and extraordinary length of the neck has been provided where the coil is attached to the bar. This is done so that the commutator necks may be refaced a great number of times and still have adequate contact area between the coil ends and the commutator bars.

The bearing and bearing housing construction represent a considerable step forward in this art. The old thrust washers and collars have been removed, and the center of the new bearing is moved about 2 inches on the average toward the shaft extension. This reduces the stress in the shaft very considerably. The new bearing is much narrower than the old, and is made of cylindrical rollers. Grease may be introduced on the outboard side of the bearing where it is stored in a large annular recess. The grease then works through the bearing and will be stored in a similar recess on the inboard side. A seal is provided to hold the grease in the housing, but if any should leak past this seal on the inboard side, a passage way is provided for it to escape down through a cored opening in the bearing housing and settle in a chamber below the bearing housing.

Presented before AISE Buffalo District Section Meeting, May 13, 1947

This chamber is open to the outside and the grease can be removed with a screw driver or any device that will scrape out the grease.

The bearing housing is clamped between the upper and the lower frame halves. A flange is provided at each end of the bearing housing which forms a pilot fit between the housing and the frame. In addition to this clamp, auxiliary clamps are provided one on each side of the bearing housing which securely fastens the housing to the lower half of the frame. This has been found to be very beneficial in the present line of motors. When a motor is dismantled, it happens very frequently that a small burr is set up on the corner of either the housing or the frame. If this burr is not removed when the machine is reassembled, it will cause the bearing housing to be separated from the fit in the frame by the thickness of the burr. As the motor operates, the burr wears down quickly and the housing is loose in the frame and wear will occur until the fault is discovered. If wear does occur in our case, it is quite a simple matter to again tighten the housing to the lower half frame by means of this auxiliary clamp, and thus eliminate the necessity of rebuilding the frame fit and reboring.

Note that our bearing housings are designed with the cap on the inside of the bearing and the housings on the outside. In normal maintenance, it is anticipated that the entire housing together with the outer race and rollers can be pulled away from the armature without dismantling the bearing housing. In case of failure of the bearing, it will be possible to remove the housing leaving the bearing and inner cap on the shaft. This then exposes the bearing and pulling jaws may readily be placed in position to pull it off.

The seals provided effectively keep the grease from getting to the inside of the motor.

The frame is made of cast steel and is split sufficiently above the horizontal centerline to permit the bolting of the commutating poles on the horizontal centerline of the motor. The upper frame half can be readily removed without disturbing these poles or coils.

Machined blocks are held in and welded securely to the frame which gives the most rigid mounting possible for the brushholder. The mounting blocks are machined so that the brushholders offset longitudinally with respect to each other a sufficient amount so that the brushes are staggered on the commutator. This is an aid to prevent grooving of the commutator. Two brush arms are used on all sizes up to and including the 612. The 614 and larger have four arms. The motor with two brush arms have a single flat commutator cover which will give liberal accessibility to the brushes and holders. The motors that have four brush arms have the covers on the 45 degree angles of the upper half frame and are arranged so that either the lower or upper brushes are accessible through these openings. These motors of course have two commutator covers.

By the arrangement that we use for mounting the brush holders, that part of the frame directly below the commutator is left free for the introduction of air in case the motor is to be forced ventilated. An opening is provided at this point and a bolted on cover closes it for normal enclosed operation. The shape of the opening is almost square and is well adapted for the addition of a pipe from the source of ventilating air. An exhaust port is arranged at the pinion end of the motor, but will normally be closed with a bolted on cover for the enclosed motor.

The two halves of the frame are hinged together by removable hinges. The hinges are dropped forged steel and are held in threaded holes in the frame halves. In case it is desired to place the motor closely against the wall these hinges can be removed readily.

Copper terminals are brazed to the conductors of the commutating and series field coils and have a drilled hole. Jumpers are readily bolted to these terminals. All connections between frame halves are brought to the outside of the motor frame before connected. In other words, the upper half frame may be removed without disturbing any connections inside the motor. The terminals of the jumpers are brazed to the copper cable which holds them securely even at very high temperatures.

The new design of field coils combines all the good features of the steel shell construction plus the better insulated properties afforded by wrapping the entire coil with tape. The field coils are wound on a mold with turns separated by asbestos paper. The coil is then completely taped with mica and glass tape in the same manner as was done on the old 40, 50, 60 Mc line. Before impregnating, the coil is assembled over a steel shell in much the same manner as the present line of MC field coils. A steel washer is then placed on top of the coil and tack welded at several places. A sheathing of asbestos paper protects the heat of the weld from damaging the glass tape of the coil. Thus the coil becomes a solid mass with the edges of the conductors all lined up even before impregnation.

The entire coil assembly with its steel shell is then vacuum and pressure impregnated in thermoset varnish which fills all crevices and voids in the assembly. The coil is assembled in the frame without the addition of any more springs, washers, or other devices. The coil is held in place by the clamping action of the pole against the back plate of the coil, and since the coil is assembled under pressure in the steel shell, there is no tendency for conductors to move after that. The conductors are just as snugly in place as the coils in the slots of the armature.

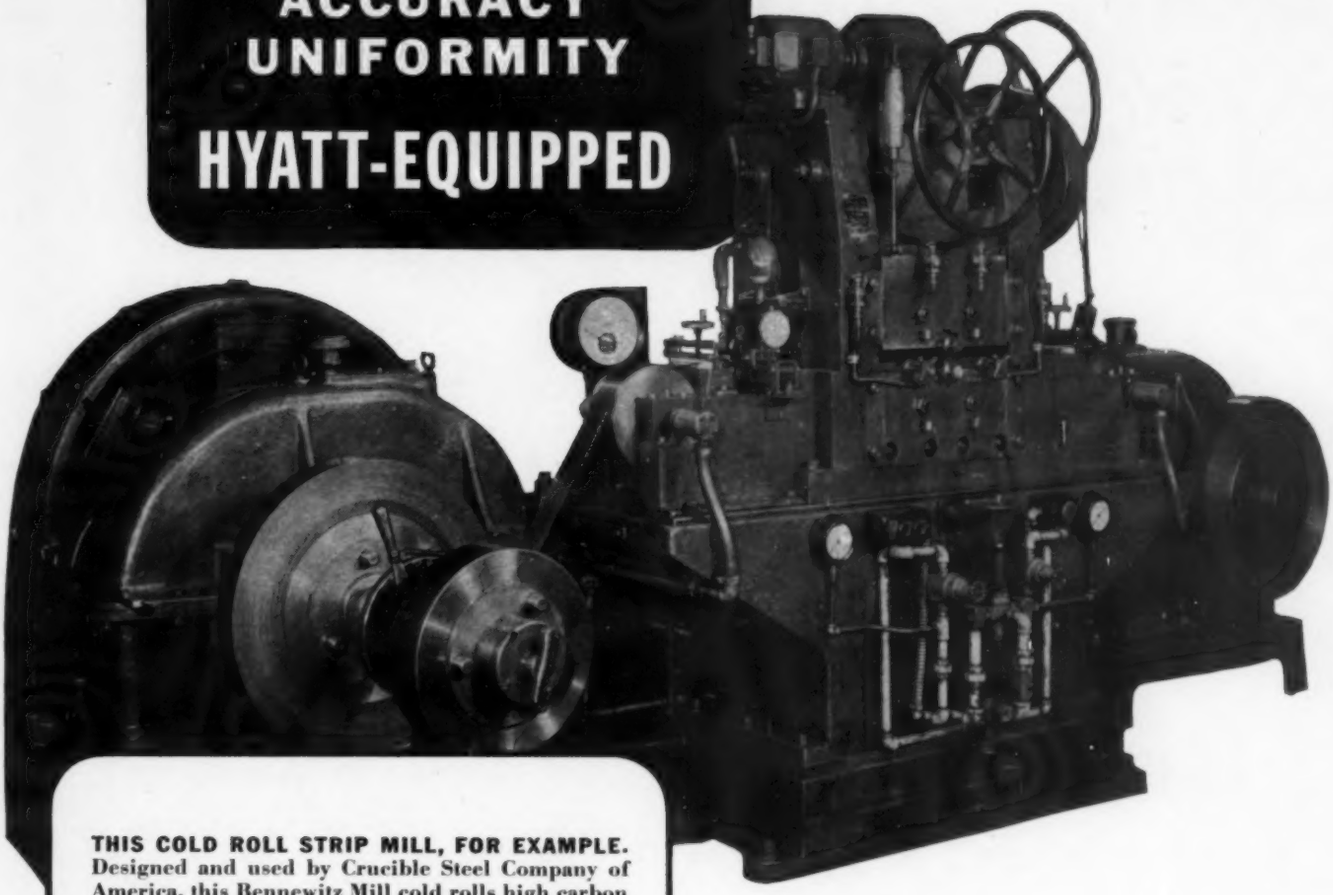
The connection between the two halves of the coils are made with brazing as is the terminal which comes to the outside. Not only is this coil well impregnated and insulated against the entrance of moisture, dirt, etc., but it is also held securely in place without extra springs and washers.

The brushholders are made of cast brass and the boxes are machined accurately for a close fit with the brushes. The pressure fingers consist of a part of the spring which only winds up and unwinds as the brushes ride up and down in the box. There are no wearing parts other than the sliding action of the brush in the box. The brushholders are attached to the mounting blocks in the frame by means of pins which are pressed into the main casting and dowelled to it. A porcelain insulating bushing is mounted over a plastic tube which fits on the supporting pins. A brass thimble protects the plastic tube from being damaged by the clamping blocks.

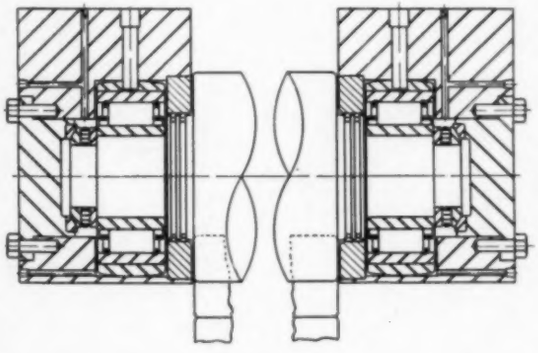
The cable is attached to the brushholders by means of a bolt. A terminal is provided on the cable. The boss on the brushholder casting to which it is bolted is a very large size so that it can be dressed down a number of times if burning still occurs at this point.

SPEED ACCURACY UNIFORMITY

HYATT-EQUIPPED



THIS COLD ROLL STRIP MILL, FOR EXAMPLE. Designed and used by Crucible Steel Company of America, this Bennewitz Mill cold rolls high carbon steel in coils 3½" wide, to thicknesses as low as .003" with tolerance on thin sizes held to plus or minus .0002". A precision operation, with remarkably high degree of finish and uniformity.

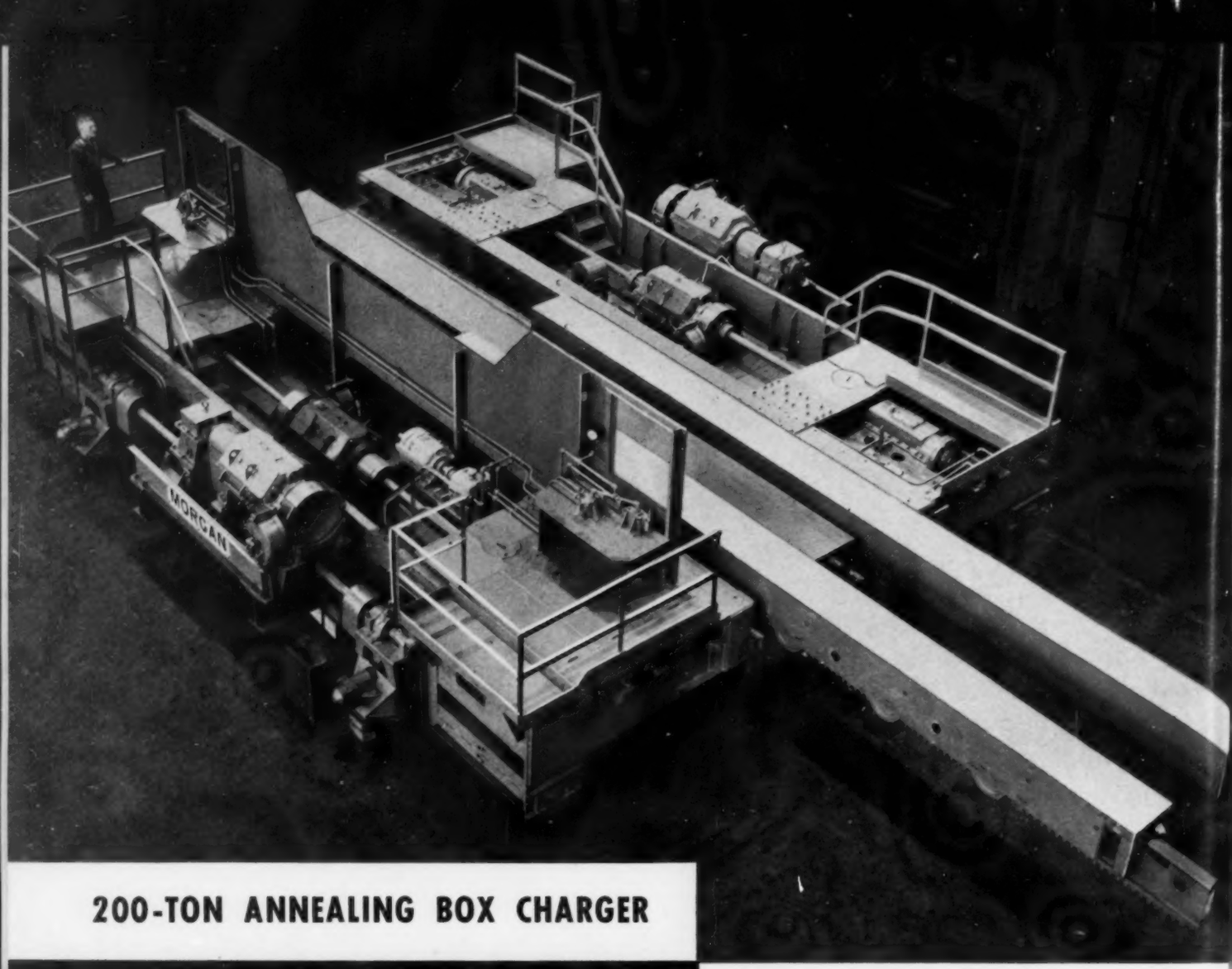


Two Hyatt Hy-Load Roller Bearings are applied to each of the four back up rolls, and provide rigid support for the work rolls. This is the result of the ingenious method of mounting . . . plus important features inherent to the Hyatt Roller Bearings themselves: their high capacity—uniformity of rollers and races—and minimum eccentricity.

From ore to finished product—in steel mills and in every branch of industry—you'll find thousands of successful applications, like this, with Hyatt Roller Bearings contributing to better design and better performance.

Fitting the bearing to the job—not the job to the bearing—is the Hyatt way of engineering. Thus, when Hyatt Roller Bearings are built into a machine, you have the assurance that the bearing is planned, manufactured and applied for your specific requirements. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS



200-TON ANNEALING BOX CHARGER

BUILT BY MORGAN Engineering

Illustrated is a Morgan 200-Ton, 5-motor, 19′-3½″ Span Annealing Box Charger. It consists of a traveling bridge upon which are mounted two rack driven charging trucks operating in unison for raising the annealing boxes and moving them into or out of the furnace or onto the cooling beds. The charging trucks are operated by two motors through four worm units with provision for operating either of the two motors alone.

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO PITTSBURGH—1420 OLIVER BUILDING

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

NEWS SUPPLEMENT MARCH, 1948

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Personnel
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Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

ELECTRIC "BRAIN" ON J & L MILL CONTROLS COILS AT 70 MPH

▲ An electric "brain" and an X-ray measuring gage, both part of General Electric control equipment, are used on the control of the world's fastest cold-strip steel mill at the Aliquippa works of the Jones and Laughlin Steel Corporation.

The mill was designed and built by the Mesta Machine Company. It features the heaviest construction of any tandem cold-strip mill for tinplate gages in the world. The machinery weighs about 4000 tons and is anchored in steel-reinforced concrete foundations which go down to bedrock 50 feet below the ground.

General Electric engineers said that the new control system makes it possible to operate the mill at a speed of 70 mph. Five-mile-long coils are rolled through the machines in less than five minutes. This is faster than any cold-strip mill has ever operated.

The "brain" of the control system is the amplidyne, a small generator of unique design, which is used as an accurate measuring and control device. In the mill control system, the amplidyne is set to maintain proper speed relationship between the motors. When irregularities in operation occur, the amplidyne recognizes and immediately corrects them. The device also makes it possible for the mill to accelerate from a threading speed of 300 fpm to more than 4500 fpm in six seconds. It also permits the speed of the machinery to be reduced from 70 mph to a standstill in six seconds.

The electric motors supply more horsepower than ever previously connected to a cold reduction mill. Combined, the motors have a capacity of 16,800 hp, and are capable of reaching more than 20,000 hp with special insulation being used. The power is supplied by two motor-generator sets with a capacity of 14,220 kw.

The other G-E feature is the X-ray thickness gage. Set to measure the thickness of the steel strip as it leaves the cold-strip mill, the gage bombards the thin metal with a beam of X-rays without physically contacting the steel in anyway. Simultaneously, a second beam of X-rays from the same source continuously penetrates a standard reference sample of steel of the same thickness.

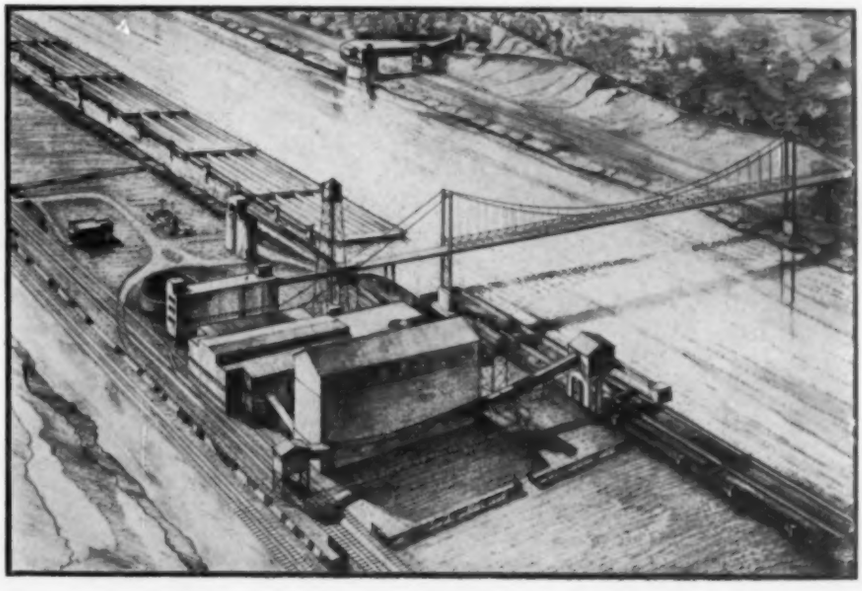
A radiation detector then measures and compares the intensities of the two beams, after they have been transmitted through their respective targets. If the intensities are the same, the rolled steel is of the desired thickness. It not, the steel is indicated to be either less or more than the desired thickness.

The new control system, the first time applied to a tandem cold-strip mill, is known as the "individual generator control system." It is so arranged that a separate generator supplies power to each of the six motors. This is a departure from conventional control systems used in the past.

Simplification of the operating problems and the ability to roll a

STEEL INDUSTRY EYES COAL CLEANING PROCESS

The steel industry, which has been faced with a decline in its reserves of high quality metallurgical coal, is watching with interest the revolutionary coal cleaning process being installed as part of the vast expansion program of the Jones and Laughlin Steel Corporation at East Fredericktown, Pennsylvania. The artist's rendering below shows the preparation plant in the foreground and a 726-foot suspension bridge which is being built to support a conveyor belt connecting the new preparation plant with the coal mines on the far side of the Monongahela River.



wider range of products on the mill are the outstanding advantages of the new system, it was explained.

This tandem mill consists of five mill rolling units or stands and a winding reel arranged in a continuous line. The strip passes successively through each stand and is wound under tension on the reel after leaving the last roll stand. The strip is reduced in thickness as it passes through each stand.

BOILERS AT CRUCIBLE INCREASE STEAM SUPPLY

▲ Steam supply at the Midland, Pennsylvania, works of Crucible Steel Company of America will be modernized and increased with the installation of two new boilers to be completed by Rust Engineering Company under a contract expected to cost $800,000.

Two Babcock and Wilcox steam generators, each capable of a peak capacity of 100,000 lb of steam at 200 psi gage and 500 F total temperature will be installed. They will be equipped to burn pulverized coal, with provisions for future burning of blast furnace gas. A pneumatic ash handling system will be installed to serve the new units.

The new units will be installed at the south end of the present No. 3 blast furnace boiler house, opposite the coal pits and track hoppers serving the present boilers. The present travelling coal crane will dump directly into the hoppers serving the new pulverizers.

Existing feedwater lines will be extended and new stacks and induced draft fans will be installed to serve the boilers. A new building extension will be built for the new boilers.

HANDLING OF LONG SHEET SIMPLIFIED BY ACCESSORY

▲The versatility of fork type electric power industrial trucks is constantly emphasized in accessory equipment. Taking full advantage of the principle of counter-balancing effect of the truck, a greater variety of loads both as to size and weight are handled. The problem of handling long sheets of steel in or out of freight cars is successfully solved by means of this combination. An Elwell-Parker electric truck, normally handling 6000 lb at 24 in. in front of the uprights, will handle a 3000 lb load of 8 ft × 4 ft or 2000 lb of 10 ft × 4 ft lengthwise, including the weight of accessory, or 6000 lb of 8 ft × 4 ft or 10 ft × 4 ft crosswise the truck. The truck has forward and backward tilt. The latter to stabilize the load when traveling, since the near end of the load rests against the uprights. The truck is furnished with telescoping uprights so that it may enter a boxcar and yet stack steel 6 ft to 10 ft high. One inch dunnage strips between unit loads facilitate the insertion of lifting lip of the suspended clamp-grab. The grab has 24 in. adjustment for widths and is 84 in. long. The truck travels at 400 fpm and elevates at 12 to 22 fpm.

WELL-KNOWN SECRETARY RECEIVES AWARD

Miss Alice Gish, secretary in the Pittsburgh office of Reliance Electric and Engineering Company for the past 25 years, received a gold watch at the annual Old Timer's dinner of the company, held recently in Cleveland. Presentation was made by J. W. Corey, Reliance president, who painted a bright future for builders of industrial electric motors in a talk which followed.

ARMCO TRADE NAME MAY BECOME FIRM NAME

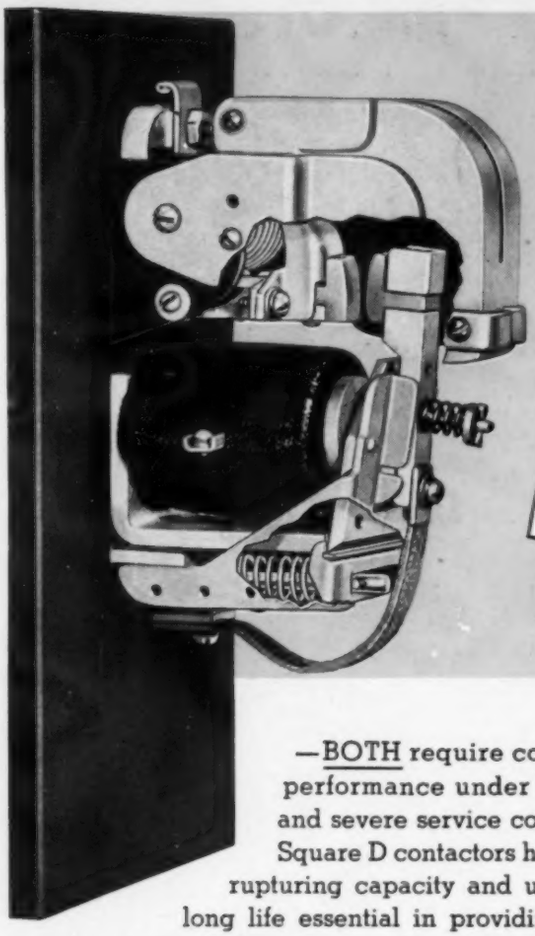
▲ A proposal to change the name of The American Rolling Mill Company to Armco Steel Corporation will be submitted to shareholders for consideration at their annual meeting on April 15, 1948, Charles R. Hook, president, announced recently.

Mr. Hook said that the change in name had been under consideration for some time. "The proposed new name utilizes the company's well-known trade name 'Armco,' and at the same time indicates that it is a steel company," he stated.

"The name 'Armco,' which is used as the trade mark to identify all our products and all the company's activities, has been the theme of national consumer advertising since 1914 and has been emphasized in all publicity since then.

"As a result of 34 years of continuous advertising, our trade name has become better known than our corporate name. Surveys made during the past several years indicate that a large segment of the public already knows us as 'Armco.' The proposed change should prove a great convenience to customers, employees, shareholders, and the public at large."

Mr. Hook also stated that the change in name, if adopted by the shareholders, "will not in any way alter or affect our long established Armco policies with respect to research, merchandising, or employee relations under which our company has grown from one small plant in 1901 to become one of the major fully integrated steel companies of the United States."



Square D HEAVY DUTY D.C. Contactors are used on BOTH Mill Auxiliary and Accessory Machine Control Panels Because...

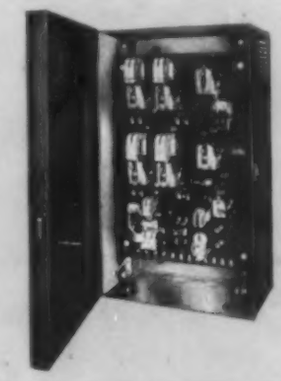
—BOTH require consistent performance under difficult and severe service conditions. Square D contactors have high rupturing capacity and unusually long life essential in providing uninterrupted production. Low inertia moving parts, knife edge bearings and strong blowouts contribute to fast operation necessary for both mill auxiliary and accessory machine control. Another important advantage—the problem of stocking spare parts is minimized through use of the same heavy duty construction.

Although identical contactors are used for both mill auxiliary and accessory machine control, the real difference in completed panels is governed by variations in assembly and construction features listed in the table below.

***Write** for information on Classes 7735, 7736, and 7950 Heavy Duty D. C. Control. Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin.*

FEATURES	MILL AUXILIARY CONTROLLERS	ACCESSORY MACHINE CONTROLLERS
Heavy duty contactors	X	X
Negative line contactor	X	
Accelerating contactors —with blowout —without blowout	X	 X
Heavy duty control relays	X	Available
Heavy duty shunt field relays	X	X
Pneumatic timers for acceleration	X	X
Overload relay 2 THERMAL-MAGNETIC	X	
1 melting alloy thermal trip		X
Terminals —mounted rear of panel —mounted front of panel	X	 X
Main line knife switch	X	
Control knife switch	X	
Control circuit fuses	X	Available
Heavy gauge sheet steel enclosures	X	X
Vault type door mechanism	X	Available
Enclosure removable back plate	X	

Class 7951 Reversing, Dynamic Braking Control for Mill Auxiliaries.



Class 7736 Reversing, Dynamic Braking Control for Accessory Machines.

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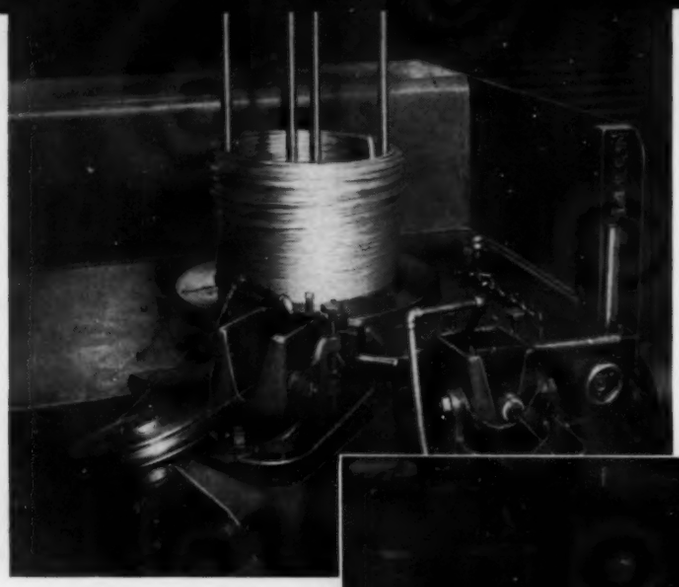

Basic Vaughn Benefits

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Flexibility
Versatility
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These Vaughn features are the perfected results of continual specialization in every type of cold drawing equipment—for every product from the finest wire to largest bars and tubes. Our broad experience is at your command. May we arrange a consultation?

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COMPLETE COLD DRAWING EQUIPMENT—Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

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...at your service

"Quick on the Draw!"
VAUGHN MACHINERY
Profitably used by leading producers since 1871

SLAB FURNACES RAISE STEEL MAKING CAPACITY

▲ Three slab reheating furnaces at Carnegie-Illinois Steel Corporation's Irvin works are being rebuilt by Rust Furnace Company. The work will increase by 50 per cent the steel-making capacity of these furnaces.

The rebuilt furnaces will supplement a new 115 ton triple-fired, zone-controlled billet heater designed and installed last year by the same contractor. When completed, the billet heating capacity of the rebuilt furnaces, together with the new unit, will total more than 450 tons.

To maintain maximum production, rebuilding of the older furnaces is being conducted so that only one unit is out of operation at a time.

The three furnaces being modernized were built by Rust originally, and put in operation in 1938. During the war they were operated at a maximum of 90 tons per hour, 50 per cent above design capacity. Their redesign permits larger heat input, and includes modern improvements that increase the capacity of each to 115 tons.

Present production schedules call for the slab reheating expansion program to be completed in late spring.

TOOL LUBRICATORS PROLONG TOOL LIFE

▲ Two new products for the metal-working industry, a drill lubricator and a saw blade lubricant, are now being marketed by Shell Oil Company. Both products were developed to prolong the life of tools and increase their operating efficiency.

The new lubricator, used principally with hand-operated automatic drills up to one-half inch, has cut drill breakage as much as 22 per cent and drilling time up to 20 per cent in plants where it is being used. The package is designed so that a rotating drill can be inserted through its top cover into the lubricant, an adjustable bottom keeping the lubricant at the top of the container. Each time the drill requires lubrication, a new hole is made in the top of the container. This insures that metal chips will be kept out of the compound when the drill is inserted and surplus lubricant removed when the drill is withdrawn.

The new saw blade lubricant, be-

A rotating drill can be inserted into the lubricant through top of container.

sides increasing cutting speeds and prolonging blade life, also reduces cutting temperatures and vibrations, permitting better sawing technique and maintenance of closer tolerances. The holder for the lubricant, which can be attached to a band saw guard, provides for automatic, self-feeding lubrication.

WESTINGHOUSE BUILDS GAS FIRED FURNACES

▲ Gas fired furnaces for annealing, carburizing, drawing, hardening, spheroidizing, malleablizing, normalizing, and dry cyaniding are now available from Westinghouse Electric Corporation. These will supplement the regular line of Westinghouse electrically heated industrial furnaces and will be designed for use with separately prepared protective atmospheres such as Exogas, Endogas, Monogas or Ammogas.

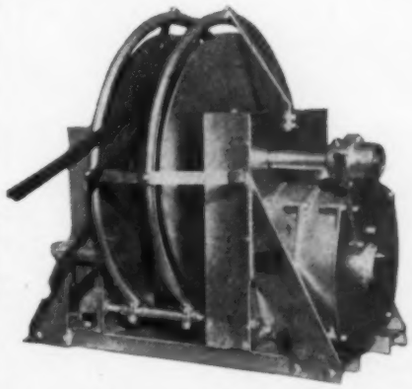
The addition of gas fired furnaces will also permit the inclusion of furnace equipment for such specific heat treating applications as gas carburizing, and dry cyaniding. Among some of the gas fired furnaces available are:

Cylindrical bell types used for bright annealing of copper wire in coils and in reels, of steel wire or strip, and other applications such as spheroidizing or drawing.

Continuous pusher types for annealing, gas carburizing, hardening, and malleablizing.

Continuous roller hearth furnaces

A NEW LINE OF
EXTRA HEAVY DUTY
GLEASON CABLE REELS



SM SERIES

Spring Driven Geared Reel
For Electric Cables
125 Amps — 600 Volts
Continuous Contact
All Ball Bearings
Two-way Payout
Non-Revolving Springs
Fabricated Steel
Watertight
Replaceable Spring Motors
Adjustable Tension
8 Standard Sizes

These reels were developed to meet the unusually severe operating conditions found throughout the steel industry and are of exceedingly rugged construction.

The spring motors are interchangeable and removable so they may be replaced without handling loose springs. Replacement springs are supplied by the factory already installed in the housings and the replaced housings are returnable for credit.

The springs are wound on extra large hubs to minimize flexing at that point.

Adjustment of the spring torque is accomplished by means of a crank handle which is removable. A lock is provided to hold the drum in position during spring adjustment.

Improved current collector and brush rigging, with extra wide spacing, minimizes the possibility of electrical troubles.

J. L. GLEASON & CO., Inc., 209 Bent St., Cambridge, Mass.

it's the TOPS!

500 Ft. Stack, Tallest East of the Mississippi

MADE WITH

SAUEREISEN No. 31 ACID-PROOF CEMENT

RIVALS HEIGHT OF WASHINGTON MONUMENT!

Washington Monument, the World's largest stone and masonry structure, towers 550 feet into the sky. The stack, pictured here, was recently erected in Pennsylvania. It is 500 feet high and was lined with acid-proof brick, laid in Sauereisen No. 31 Acid-Proof Cement. Over 480,000 lbs. of Sauereisen Acid-Proof Cement No. 31 were used on this job.

USED ON BIGGEST JOBS

This is just an example of hundreds of case histories in our files that demonstrate the satisfaction large users obtain from this superior acid-proof cement. Thousands of tons are now in place on masonry constructed tanks, towers, vats, pits, floors, filters, and receivers.

QUICK SETTING— GREATEST STRENGTH

Sauereisen No. 31 Acid-Proof Cement hardens rapidly but remains soft and pliable enough to permit ample time for handling. It is ready to use by simply mixing a powder and liquid. Applies like ordinary mortar. It is the strongest sodium silicate cement available for acid-proofing. A trial order must convince or there will be no charge.

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MANUFACTURERS OF INSA-LUTE (Liquid Porcelain)

Prove it yourself!

ORDER A TRIAL BAG

SAUEREISEN CEMENTS COMPANY
Pittsburgh 15, Pennsylvania

Gentlemen:
Ship a trial 100 lb. bag of Sauereisen No. 31 Acid-Proof Cement at $12.00.

Name.....

Street.....

City.....State.....

Date.....By.....

for applications such as cycle annealing, hardening, malleablizing, and drawing.

Continuous conveyor furnaces for heat treating applications where light and medium weight parts are involved. Typical applications are annealing, drawing, and certain limited brazing and sintering applications.

PIPE MILL IN WEST INCREASES SUPPLY

▲ Completion of Kaiser Steel's Fretz-Moon pipe mill at its Fontana, California, plant has resulted in a new supply of vitally needed commercial and plumbing pipe for Western industry and home builders.

The new mill, first of its kind west of the Mississippi, is now in production and will turn out 90,000 to 125,000 tons of pipe annually in sizes ranging from half-inch to four inches in diameter.

The new mill is part of Kaiser Steel's expansion program to meet the West's growing needs, and will help overcome serious material shortages now facing the nation.

Kaiser officials said that Fontana's merchant mill has been altered and augmented to enable it to produce skelp in coils necessary for the manufacture of pipe, and that both black and galvanized pipe can be produced by the butt-welding process.

RELIANCE PURCHASES DETROIT STEEL PROPERTY

▲ A joint announcement was made today by the Detroit Steel Corporation and the Reliance Electric and Engineering Company, of the sale to the latter of the land and buildings at 1170 Ivanhoe Road, Cleveland, Ohio, occupied for the past ten years by the Detroit Steel Corporation's Cleveland branch as a steel warehouse and distributing plant.

This property was originally owned by the Connelly Boiler Works and at one time was also occupied by the Foster-Wheeler Corporation of New York.

The acquisition of the property by Reliance Electric and Engineering Company will substantially increase the already sizable holdings of that company in the eastside industrial area of Cleveland. Its main plant and general offices are also on Ivanhoe Road, a short distance from the Detroit Steel property.

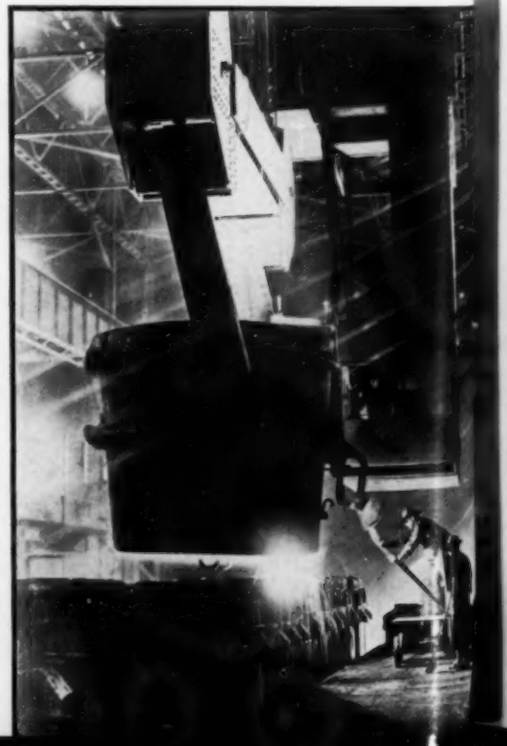
Detroit Steel Corporation announces also that, as a further step in its overall expansion and modernization program for 1948, plans are underway for a new plant for its Cleveland branch. The new plant will be designed and constructed to better meet the needs of modern steel warehousing and distributing operations. Disposal of the present plant is in accordance with such plans.

So that Detroit Steel may continue to serve its Cleveland customers with the least amount of interruption until its new plant is ready, arrangements have been made with Reliance Electric and Engineering Company to share occupancy of the premises during the transfer period, which may embrace several months.

Both the seller and the purchaser emphasize the fact that the announced transaction involves only the land and buildings at 1170 Ivanhoe Road. The existing processing equipment, supplemented by new facilities, will be moved to Detroit Steel Corporation's new Cleveland plant.

CRANE CAB COOLER USED ON LADLE CRANE

Despite extremely high temperatures in the surrounding area, the operator of this 185-ton ladle crane at the Jones and Laughlin Steel Corporation, Aliquippa works, is kept comfortable because his cab is air conditioned by a Dravo crane cab cooler. Six other crane cabs at Jones and Laughlin also are equipped with these units.



ALUMINUM imposes NO PROBLEMS of CONDUIT LAYOUT

Compare conduit sizes when you *figure it in aluminum!* The chart shows identical capacities of aluminum and copper motor leads. In four out of five cases, conduit sizes are identical. In the remainder, only a simple change to the next size conduit is needed.

Cut over-all job costs by specifying insulated wire and cable made with Alcoa E.C.* Aluminum Conductors . . . *the conductors of the present and future.* You'll face no problems—of conduit lay-out, of conductivity, or of joints and terminals.

Alcoa is supplying light, conductive E.C. Aluminum to leading wire and cable manufacturers. They draw, strand, and insulate it, and sell it under their own trade-marks. Obtain it from your regular wire and cable supplier. ALUMINUM COMPANY OF AMERICA, 2128 Gulf Bldg., Pittsburgh 19, Pennsylvania.

*E.C.: *Electrical Conductor* Aluminum

ALCOA EC ALUMINUM

FOR ELECTRIC WIRE AND CABLE

"MULTICUT" "TUFCUT" "HOT WORK"

Wapakoneta
SHEAR BLADES
and ROTARY KNIVES

Any type or size blade of proper Alloy with correct hardness and temper for every type shearing machine and every kind of job.

Rx ENGINEERED TO THE JOB

Every Wapakoneta blade is made to exact specifications, designed for the particular job. Complete records with order number of each blade makes possible duplication of exact size and temper at any time.

The WAPAKONETA MACHINE CO.
Shear Blade Specialists Since 1891
Wapakoneta, Ohio

FOUR SYSTEMS LUBRICATE NEW 70 MPH STRIP MILL

▲ Four separate lubrication systems are required to lubricate the new five-stand tandem mill at the Aliquippa works, Jones and Laughlin Steel Corporation, during operation.

Massive rolls weighing up to 27 tons, turning at velocities required to cold roll steel strip at speeds up to the unprecedented maximum of 6250 feet per minute, have made large capacity systems essential.

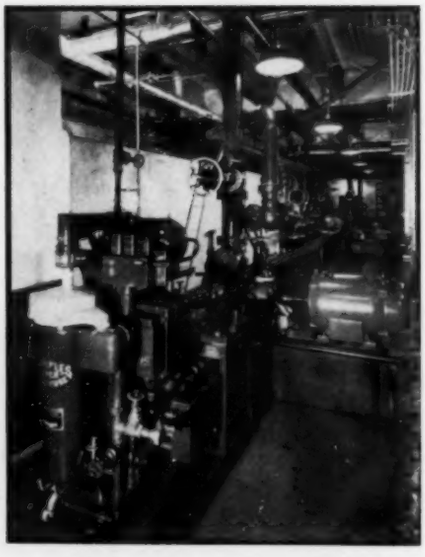
The huge back-up rolls are lubricated by a special recirculating oil system. A similar system supplies oil to the drives and screwdowns during operation. The work rolls on the mill are lubricated by an extreme pressure grease. In addition, the strip is coated with palm oil by another system to act as a lubricant between the strip and the rolls of the mill while the strip is being rolled.

The oil reservoirs for the back-up roll bearing system consists of two 14,000 gallon tanks for holding the oil and maintaining it at a constant temperature of about 110 F.

This temperature is maintained by a unique steam heating system through which the oil is circulated. There are no heating pipes in the oil tanks.

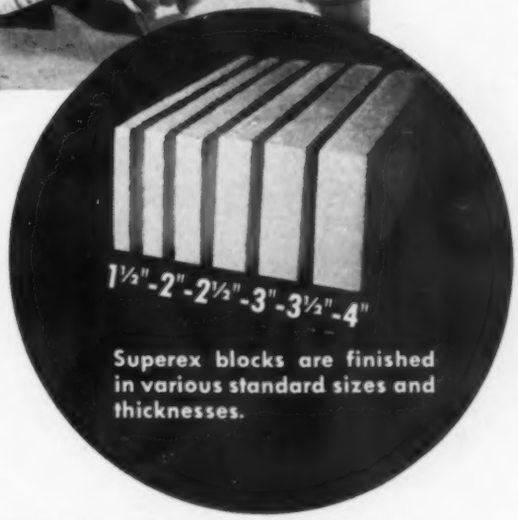
Oil is pumped from these tanks by

Shown here is one part of the "oil cellar" to the world's fastest tandem mill. The tanks at left hold lubricant for the back-up roll bearing system. The two oil pumps in the right foreground and right rear are each 280 gpm capacity pumps. In the left foreground is a centrifuge for cleaning the oil in one tank while the other tank is being used during operation of the mill.



"What block insulation shall we use?"

"SUPEREX, it's been our standard for over 20 Years"



Superex blocks are finished in various standard sizes and thicknesses.

• For temperatures to 1900 F, Superex is used more than any other block insulation behind refractory linings of hot blast stoves, mains, bustle pipes, kilns, regenerators, roasters, flues, stacks, industrial and metallurgical furnaces, stationary and marine boilers and auxiliary power plant equipment.

These seven outstanding advantages have made Superex the leading block insulation:

1. Low Thermal Conductivity—Superex is made from specially selected calcined diatomaceous silica, bonded with asbestos fibre—presenting a formidable barrier to the passage of heat.

2. High Heat Resistance—J-M Superex Blocks safely withstand temperatures up to 1900 F without deterioration.

3. Light Weight—Approximately 24 lbs. per cu. ft.

4. High Physical Strength—Withstands vibration and other physical abuse encountered in normal service. Approximately five tons pressure per square foot are required to compress Superex ⅛ inch.

5. Permanent Efficiency—Superex maintains high thermal efficiency indefinitely—will not disintegrate in service for which recommended.

6. Quick Application—The convenient sizes and light weight of Superex assure fast, economical installations.

7. Easy Cutting and Fitting—Superex is easily cut with an ordinary knife or saw for fitting around openings or irregular surfaces.

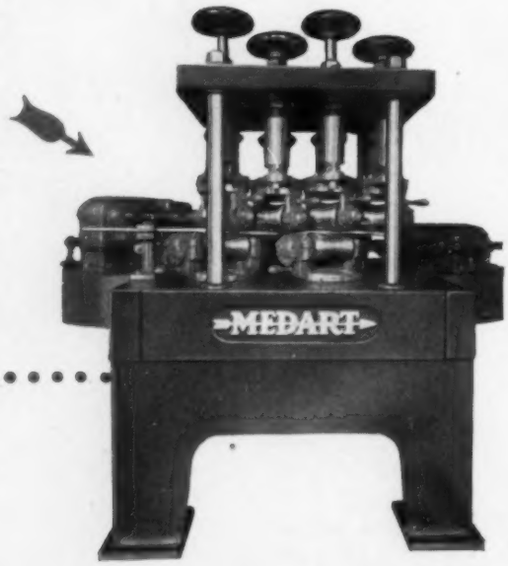
Special shapes or curved blocks—in addition to the 6 standard thicknesses illustrated—can be supplied. Write Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE *First in* INSULATIONS

MEDART MICRO-MULTICYCLE!

straightening machine designed exclusively for ⅛" to ½" bars and tubing.

Small, compact yet built on the same principle and embodying the same advantages as the Medart 6-in-1 Multicycle Straightener . . . positive, synchronized feed . . . one feeding level . . . two bending cycles . . . single motor . . . and the Medart Micro-multicycle has this PLUS FEATURE: all six rolls are driven! A variable feed-speed range is built into the machine. 3 H. P. motor mounted on base of machine.



MANUFACTURING ENGINEERS OF COMPLETE TRANSMISSION EQUIPMENT AND SPECIALIZED MACHINERY

MEDART

THE MEDART COMPANY • 3500 DEKALB ST. ST. LOUIS, MO

two 285 gallon capacity pumps, arranged so that one pump is in continuous operation, and in the event of a pressure drop, the second pump becomes operative.

From the pumps, the oil is forced through a filter with multi-rotating cylinders with 0.005 in. openings, which is automatically cleaned.

If the pressure differential exceeds ten pounds, an automatic warning signal gives an indication, and if the differential reaches 18 pounds, the oil will automatically by-pass the filter.

From the filters, the oil is passed through coolers where it is given an even temperature of 100 F, then it is piped at a controlled pressure to the back-up rolls. These massive rolls, when turning at high speeds, are actually suspended on a film of oil.

After being circulated through the bearing, the oil returns to the reservoir.

The temperature of the oil from each back-up roll bearing is continuously registered on an automatic recorder. The operators watch these carefully to guard against any abnormal temperature rise and to observe any indication of trouble in a bearing. In the event of a sudden drop in oil pressure, additional warning is given them by use of red and green lights on the mill itself.

Repeated laboratory tests of the oil in the reservoir determine its degree of contamination. When oil in one 14,000 gallon tank becomes slightly contaminated, it is taken out of service and the oil in the second tank is put in use. The oil in the contaminated tank is then pumped into a scavenger tank and heated.

It is then slowly passed through a centrifuge whirling at 15,000 rpm which removes the contamination. The oil is then returned to its reservoir thoroughly cleaned, for use when the second tank becomes contaminated.

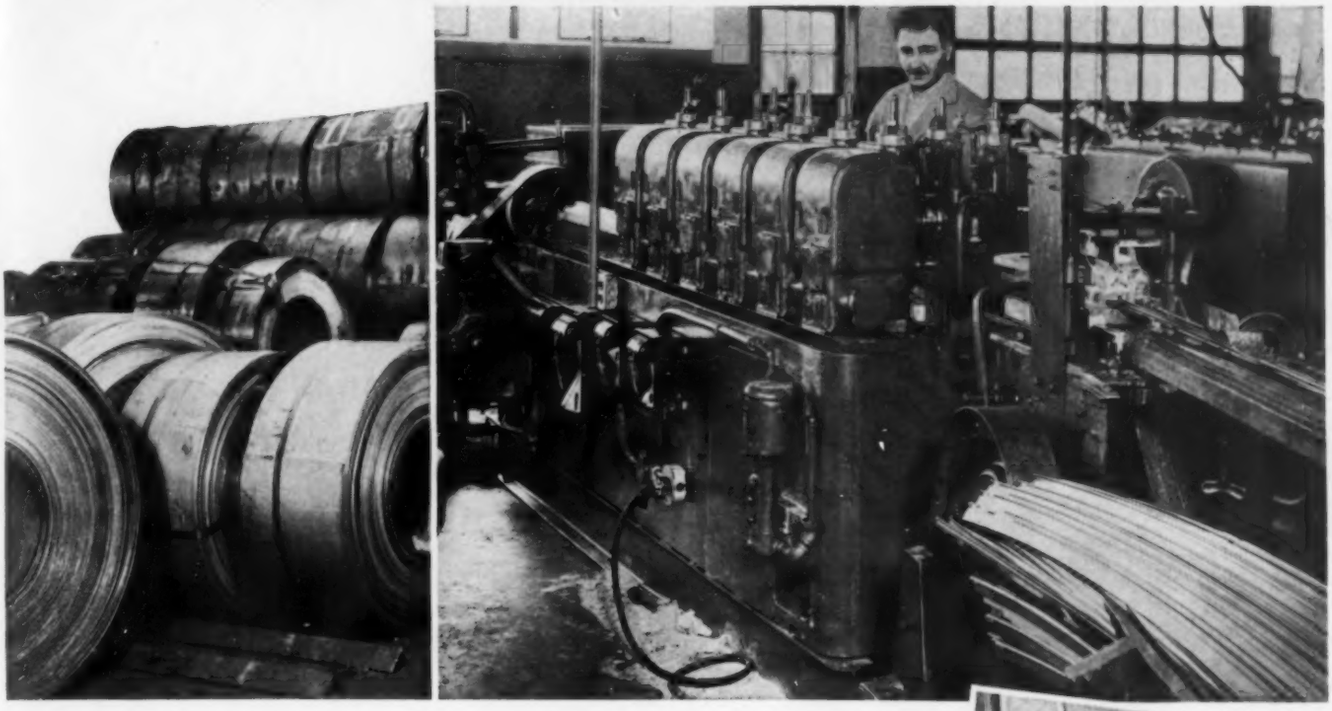
The pinion oil system is similar in operation, consisting of one 8000 gallon capacity tank where special extreme pressure oil for lubrication of drives and screwdowns is held.

It is circulated by two 200 gallon capacity pumps through filters and a cooler identical to those for the back-up roll bearing system, and on return can be cleaned through a recirculating filter system.

Grease pumps supply extreme pressure lubricant to the work roll bearings and the back-up roll thrust bearings in predetermined amounts

THE SEVEN BIG ADVANTAGES OF COLD-ROLL-FORMING

STRUCTURALS | TUBING
MOULDINGS | TRIM



Series of Seven

No. 7. Small Inventories

● Owners of Cold Roll Forming machines are able to reduce their inventories to a minimum because they can, on a few hours' notice, from flat rolled metal produce any special shape for which they have rolls or tooling.

The sudden discovery that they are completely out of an urgently needed item need not disturb them, because they can begin to produce it within the 3 to 4 hours normally required for the average roll change.

Partly for this reason, and partly because the average production of a Yoder Roll Forming machine, with one operator, is upwards of 38,000 feet per 8-hr. day, the owners need not go in for long runs, building up big inventories, in order to keep conversion cost far below that obtainable by any other method.

By and large, it is obvious that the required widths and thicknesses of coiled or flat sheets or strip are, even in times like the present, much more readily obtained than are special made-to-order hot rolled or extruded shapes.

If, in addition to a Yoder Cold Forming Machine, you also have a Yoder Slitting Line, your day-to-day requirements of special widths can be even more quickly met, and inventories of flat rolled stock still further reduced. Literature, estimates and recommendations are yours for the asking. No obligation, of course.

THE YODER COMPANY
5495 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING

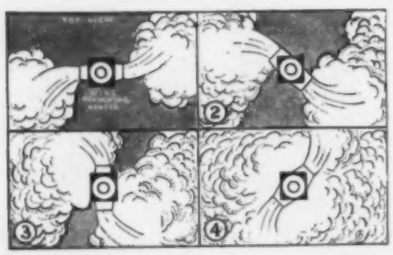
ROLL FORMING, TUBE MILL AND SLITTING MACHINERY

36 YEARS' LEADERSHIP • COILING • SLITTING • FORMING • EMBOSSING • CURVING • WELDING • CUTTING-OFF

Revolving Unit Heaters Insure Complete, Thorough Coverage Regardless of Obstructions ★ ★ ★

Not just another unit heater, the WING REVOLVING HEATER is unique in that it does what no other heater can do — its slowly revolving outlets gently distribute the heat continuously in a constantly changing direction. It reaches over, around and under obstructions into out-of-the-way corners, its moving streams of heated air quickly warm up a plant in the morning. Its properly warmed, healthful air currents thoroughly distributed, create a sensation of live, invigorating comfort for the workers. Wing Revolving Unit Heaters are used in many of the country's leading industrial plants. Write for a list of installations.

Wing
Revolving
UNIT HEATERS



1. Heater starts. 2. 15 seconds later, 45° revolution. 3. 30 seconds later, 90°. 4. 45 seconds later, 135° revolution.

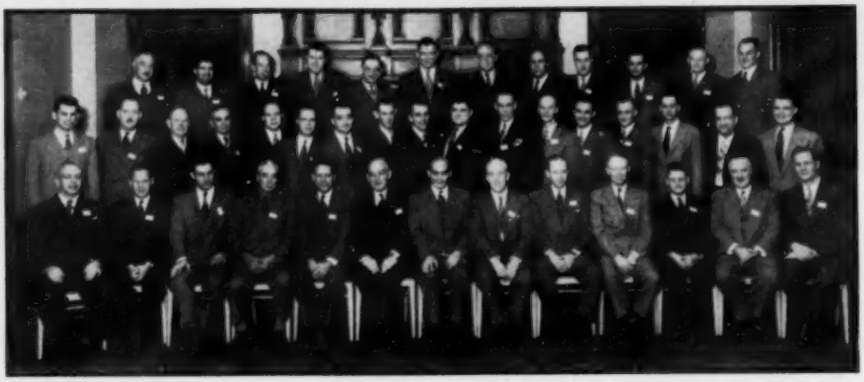
Wing Revolving Unit Heaters keep the heated air moving in a constantly changing direction. Its properly warmed, healthful air currents throughly distributed, create a sensation of live, invigorating comfort for the workers.

Write for Bulletin HR-5.

L. J. Wing Mfg. Co.

142 West 14th Street, New York 11, N. Y.
Factories: Newark, N. J. and Montreal, Canada

TRANSFORMER FIRM HOLDS SALES MEETING



Pennsylvania Transformer Company's sales representatives from all over the country gathered in Pittsburgh for their annual sales conference recently. Those attending were left to right: Front row — Lester H. Colbert, Cleveland; B. L. Farmery, Philadelphia; Robert P. Kewley, Denver; Harry S. Davis, Minneapolis; William C. Dorn, Philadelphia; George R. Horne, Dearborn, Michigan; Samuel Horelick, Pittsburgh; John G. Corrin, Los Angeles; W. R. Swoish, Pittsburgh; James E. Murray, Kansas City, Missouri; J. D. Swafford, Kansas City, Missouri; Raymond K. Kyle, Washington, D. C.; Lewis A. Beck, Denver. Second row — Arnold Horelick, Pittsburgh; Walter V. Gearhart, Atlanta; Charles H. Douglas, St. Louis; L. Clair Mitchell, Pittsburgh; H. J. Randolph, Boston; J. J. Costello, Jr., Boston; Carl R. Boytano, Boston; E. P. Gallagher, Dearborn, Michigan; Harold W. Kanzler, Spokane; William J. Ash, Toledo; Fred W. Carlson, Seattle; J. E. Nelson, Indianapolis; Lynn R. Silver, Salt Lake City; Rush F. Young, Pittsburgh; William G. Swoish, Atlanta; Frank Fraietta, Pittsburgh; Irving R. Isaacs, Pittsburgh. Third row — Harry J. J. Fisher, Cleveland; C. F. Dunn, Shreveport, Louisianna; Edgar S. Banghart, New York; O. C. Skeeters, Dallas; Clarence R. Silver, Salt Lake City; Gary W. Peters, Cuyahoga Falls, Ohio; N. M. Mintz, Chicago; Charles S. Brangan, Philadelphia; James M. Nelson, Indianapolis; Richard J. Fox, Washington, D. C.; George E. Honn, San Francisco; and J. Barry McCabe, Pittsburgh.

and at predetermined time intervals.

Palm oil for lubrication of the strip during rolling is mixed with water in a mixing tank in desired proportions, then pumped to the mill by 42 pumps. Each pump distributes the palm oil and water mixture to the strip at predetermined rates while the strip is in motion.

The palm oil mixture is spread on the strip by spreader rolls on top and underside. On its return, the palm oil and water mixture is pumped through a recovery system to reclaim the palm oil for other usage.

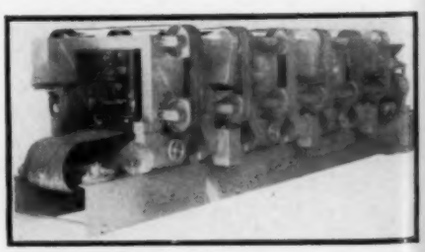
To protect the lubricating systems from possible fire damage, the oil cellar is equipped with an automatic fire control apparatus which will flood the entire area with two tons of carbon dioxide at a temperature of about 0F for a period of two minutes.

Planned under supervision of Mesta Machine Company, the installation of the entire system was made by the Bowser Company, Inc.

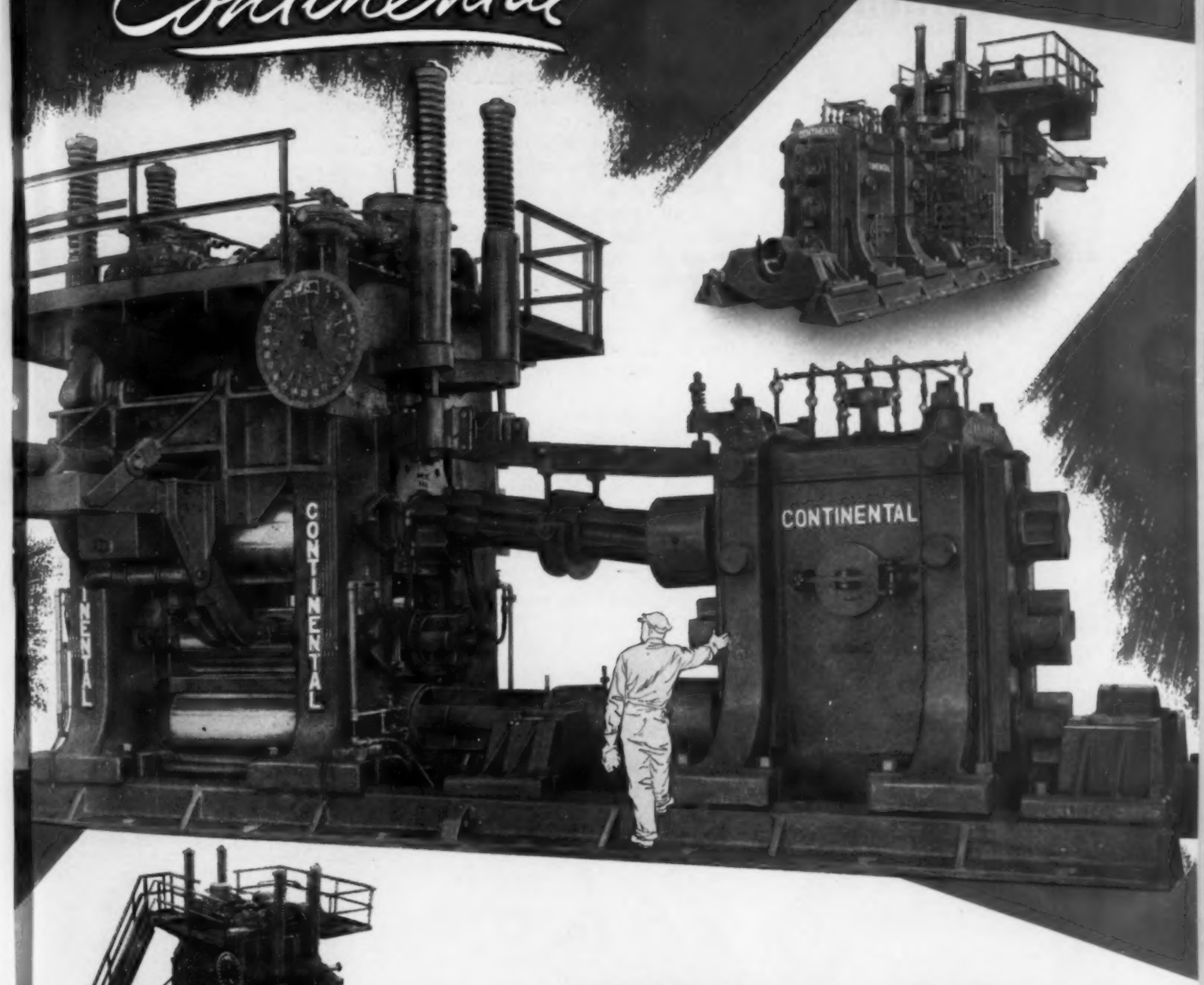
MAGNETIC SEPARATOR CONCENTRATES MATERIAL

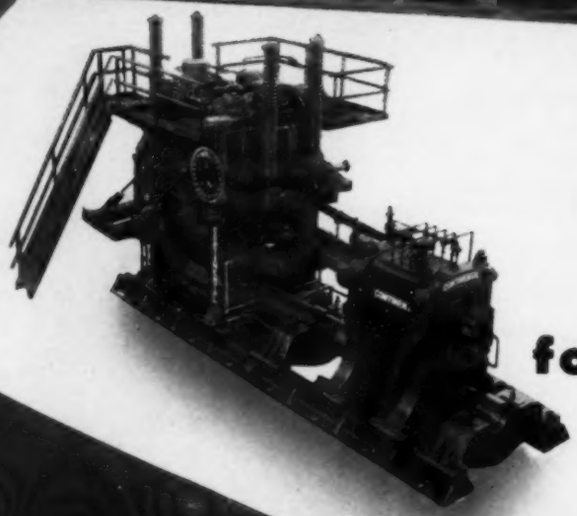
▲ A new super-high-intensity cross belt magnetic separator is announced by the Dings Magnetic Separator Company, for concentration and purification of magnetic and non-magnetic materials. A few of the materials separated — some of these never before separated magnetically — include: ilmenite, monazite, chromite, garnet, epidote, wolframite and phrrotite. Weakly magnetic materials previously lost in the tailings can be concentrated into their separate, purified and salable forms. Separator is available with any number of cross belts: an eight belt unit, for example, being capable of concentrating eight separate magnetic products and one non-magnetic. This is accomplished by varying the strength of each cross

This is one of the more recent developments in high intensity separators.



Continental

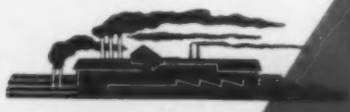




SPECIAL MILLS
for the *New Alloys*

Widely diversified experience in the design and construction of rolling mills for both usual and unusual products qualifies CONTINENTAL as your FIRST CHOICE for rolling mill equipment.

Continental
FOUNDRY & MACHINE CO.
CHICAGO · PITTSBURGH
Plants at: E. Chicago, Ind.; Wheeling, W. Va.; Pittsburgh, Pa.

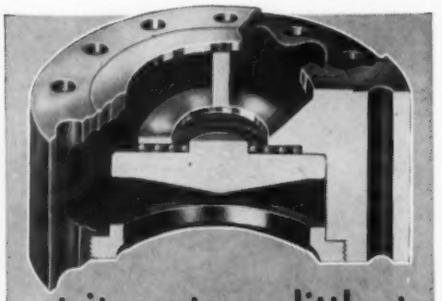


Industry's Headquarters for Rolling Mills and Equipment Iron and Steel Mills and Alloy Steel Castings

WATER HAMMER

can cost

a Fortune



yet it costs so little to correct with

THE WILLIAMS-HAGER *flanged* SILENT CHECK VALVE

Used and specified on hundreds of new buildings—and installed on thousands of old buildings to prevent costly "Water Hammer" —the Williams-Hager Flanged Silent Check Valve will solve your problem, too! Write for new technical bulletin.

THE WILLIAMS GAUGE CO.

Pump Valves . . . Water Gauges . . . Gauge Cocks . . . Steam Traps . . . Pump Governors . . . Feed Water Regulators . . . Water Columns

3076 PENNSYLVANIA AVE. · PITTSBURGH (12), PA.

belt magnet, permitting the separation of materials having different magnetic susceptibilities, as well as separation of magnetic from non-magnetic materials. A high degree of selectivity is obtained through use of three features: (1) extremely high intensity magnetic pole (patent applied for), (2) hand wheel adjustment of air gap to increase or decrease the concentration of flux lines at pole nose, and (3) variable speed drive on main conveyor belt — all of these features allowing for a control of the amount and type of magnetic material removed and also making possible a successive separation of different materials by each unit. Most important new feature is construction of pole noses on each cross belt unit — each as strong as individual cross belts in old design — which results in a separating capacity twice as great. This also means a greater capacity on the main belt, thus reducing the number of cross belt units required. A highly efficient closed magnetic circuit is utilized, permitting the lowest possible loss of leakage flux, and hence the highest efficiency. Separate magnetic circuits and pole adjustments for each cross belt assembly provide quick and easy adjustment.

BOOTH 454
Show and Sell your equipment, supplies and services to the Steel Industry
at the 1948 IRON & STEEL EXPOSITION
CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO
Sept. 28, 29, 30, Oct. 1, 1948

Phone, Wire, or Write

ASSOCIATION OF IRON & STEEL ENGINEERS

1010 Empire Building, Pittsburgh, Pa.

ATlantic 6323

PIG CASTING MACHINES USE MANGANESE STEEL

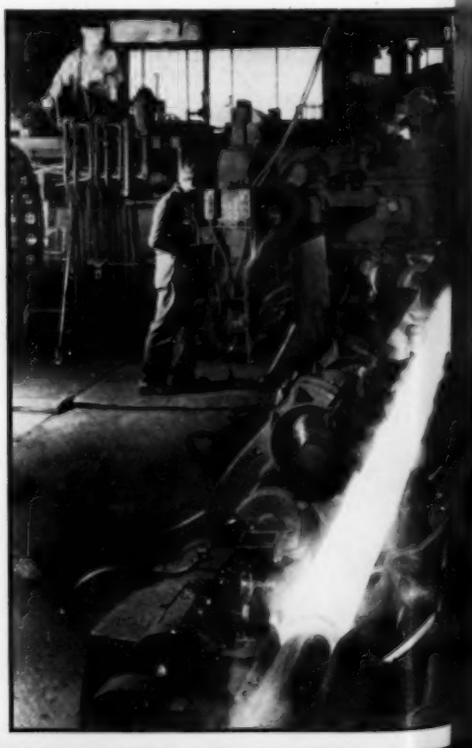
▲ A substantial contribution has been made toward the continuous operation and lower cost of maintenance of pig casting machines by the use of manganese steel, produced by American Manganese Steel division of American Brake Shoe Company, for the parts that must withstand shocks, stresses and abrasion. The chain and rollers of the endless conveyor that carries a series of molds to the pouring station are subjected to abusive treatment.

It was the practice, with the earlier pig casting machines, to make the pig machine rollers or wheels in chill molds from blast furnace iron. Replacements, as one steel mill superintendent put it: "became so frequent as to be a serious handicap to our continuous operation." Chain of ordinary steel likewise failed to stand up well in this gruelling service.

Manganese steel wheels, chain links and pins have demonstrated to the

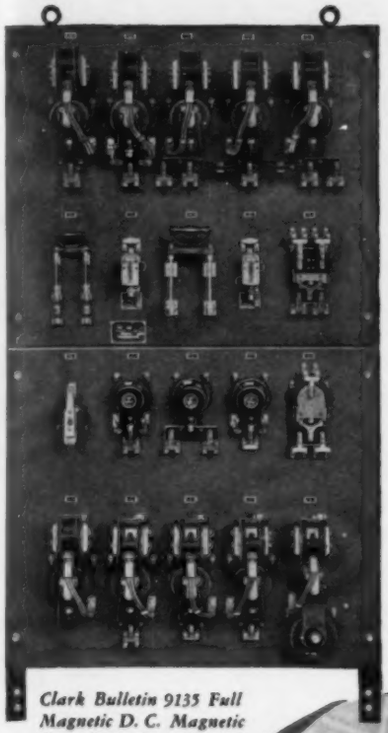
TUBE MILLS SET RECORDS

This U. S. Steel seamless pipe mill and a sister mill at National works of National Tube Company, McKeesport, Pennsylvania, recently achieved all-time records for the production of pipe that will be used to help ease the country-wide fuel shortage. Together, in January, the plant's two seamless hot mills turned out 54,344 tons of pipe, topping by more than 4000 tons the old record made in October, 1946. Sharing the spotlight is the plant's finishing department, which handled 52,729 tons in January as against the best previous monthly mark of 50,042 tons in October, 1946.



CLARK D. C. Crane Control *provides—*

SAFETY
CONTROLLABILITY
SERVICE

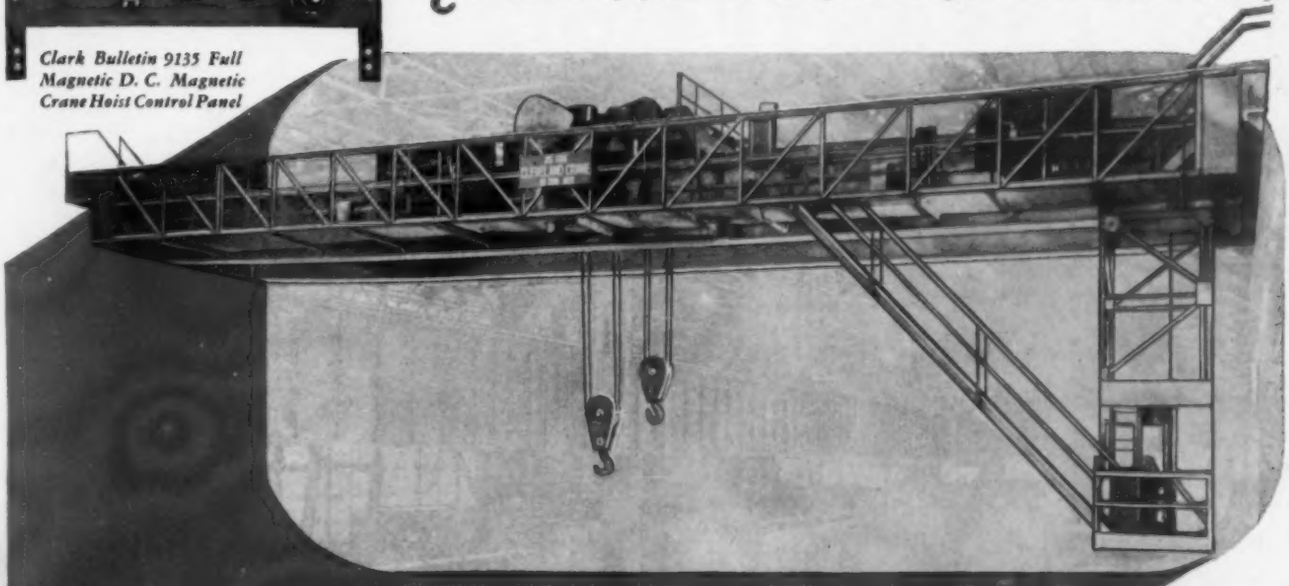


Clark Bulletin 9135 Full Magnetic D. C. Magnetic Crane Hoist Control Panel

SAFETY—With CLARK D. C. Magnetic Crane Hoist Controls, it is practically impossible to drop a load. This is true even with power failure, tripping of overload relay, or magnetic brake failure, *regardless of load* or position of master switch.

CONTROLLABILITY—CLARK D. C. Magnetic Crane Hoist Control provides *s-m-o-o-t-h* acceleration—pick-up without jerking. In lowering, there is a minimum of differential in hook speed *regardless of load*, for each point on the master switch. Automatic high-speed light hook lowering increases crane output.

SERVICE—All apparatus is Heavy-Duty Mill-Type, requiring minimum maintenance. Accelerating contactors are the famous CLARK Vari-Time, thereby reducing the total amount of equipment and wiring. Common parts of all units are interchangeable.



For Complete Magnetic Crane Control Use:

- CLARK Bulletin 9135 FULL MAGNETIC D. C. CRANE HOIST CONTROLLERS
- CLARK Bulletin 9136 FULL MAGNETIC D. C. BRIDGE TROLLEY CONTROLLERS
- CLARK Bulletin 106 D. C. SHOE BRAKES
- CLARK Bulletin 101 MILL MASTER SWITCHES
- CLARK Bulletin 110 EDGEWOUND RESISTORS

SHIPMENT—
6 to 8 weeks on standard equipment.

EVERYTHING UNDER CONTROL

THE CLARK CONTROLLER CO.

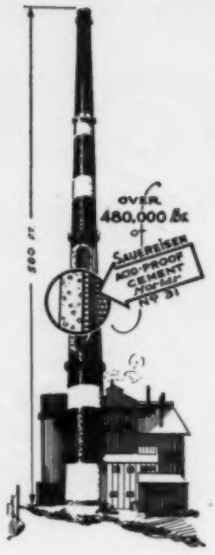
1146 EAST 152nd STREET, CLEVELAND 10, OHIO

satisfaction of those mills using them for pig casting machines that they reduce costs and last much longer than chilled iron castings. These results come from manganese steel's unequalled toughness that withstands shocks and stresses; and its characteristic surface hardening from cold-working that gives it remarkable abrasion resistance. In most cases the manganese steel wheels weigh about half as much as the chilled iron wheels; made possible by the greater toughness and shock resistance of manganese steel. The lighter weight, besides saving metal, requires less power to operate the conveyor.

Pig casting machines are but one of the applications where manganese steel has proved profitable in blast furnace, rolling mill and other steel plant operations.

ACID PROOF CEMENT FOR STEEL INDUSTRY

▲ The chimney shown in the accompanying illustration is 500 ft high (50 ft shorter than the Washington Monument) of dual construction. The outside of the chimney is concrete and inside is a brick chimney. It required over 90 carloads of acid proof brick which were laid in Sauereisen



acid proof cement No. 31. Over 480,000 lb of this special cement were used, which is supplied as a powdered filler, and a liquid binder.

Acid proof brick masonry is just coming into its own in America, where it was introduced about 25 years ago. The difficulty was to find a chemical set cement which would work like other building cements and would not require long periods of artificial drying like the old style silicate of soda cements.

Sauereisen Cements Company introduced acid proof brick masonry into the steel industry making modern production records possible. Another development was the laying of acid proof brick floors using ordinary paving brick and Sauereisen cement in modern strip mills.

This company produces over 2,000,000 lb of special scientific and technical cements annually for all industries. It is a highly specialized business which requires the know-how of many industries and the practical skill not obtainable from text books.

A data sheet and indexed price chart is available which includes a chart listing over twenty of their many technical cements for acid proof construction, electrical insulation, sealing, assembling and pipe jointing. It gives application data, technical characteristics, weights and prices of the cements, shipping containers and other detailed information.

BLOOM

BAFFLE TYPE BURNERS

FOR COVER TYPE FURNACES

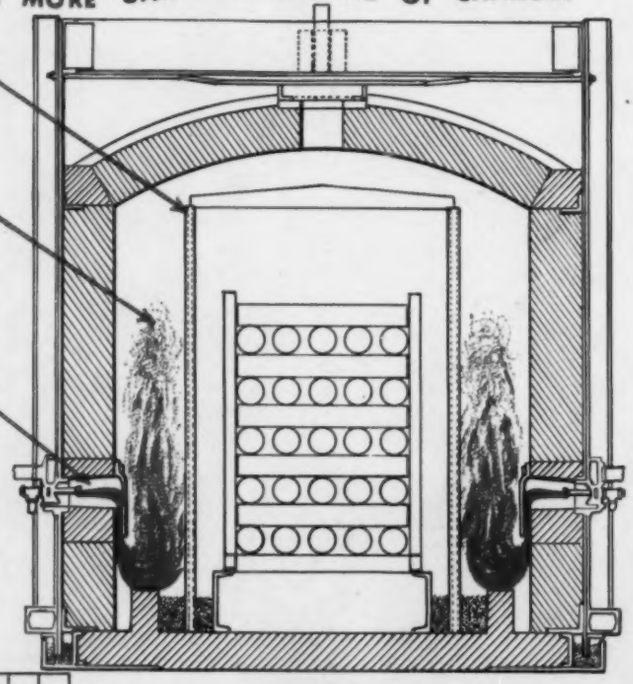
GIVE FASTER, MORE UNIFORM HEATING OF CHARGE!

Top of charge will take care of itself when heat is driven to bottom of furnace.

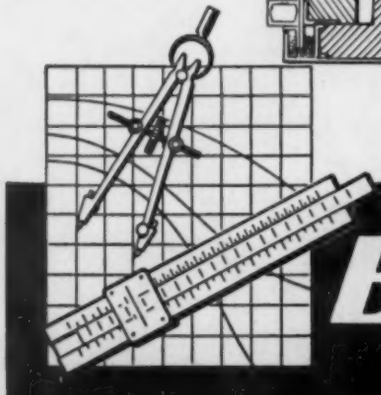
Bloom Burners are suitable for use with coke oven or natural gas.

Baffle Burner diverts flame downward, thus concentrating heat at the bottom of the charge where it is so badly needed.

Charge heats faster, because Bloom Baffle Burners produce a flat luminous flame of high radiating power.



...another example of how Bloom Engineered applications are serving industry.



BLOOM ENGINEERING CO.

857 W. North Avenue Pittsburgh 12, Pa.

Where

Rolling Alignment

"PAYS OFF!"

Rolling alignment—that's the BIG thing that steel mill men like about SKF Spherical Roller Bearings. It compensates for errors in machining and setup. It accommodates deflections, distortions or weave when tables wear and rolls warp. In the application below, SKF Bearings were easy to install . . . are protected by rugged, triple-sealed SKF Pillow Blocks. Abrasives and corrosives can't reach them. Lubricant can't escape. Submit your designs for proposal . . . TODAY. 6401

SKF INDUSTRIES, INC., PHILA. 32, PA.

SKF

Ball & Roller Bearings

● SKF Bearings and SKF Pillow Blocks as applied to run-out tables from a shear unit built by United Engineering & Foundry Co.

ROLL ROUGHING UNIT RAISES PRODUCTION

▲ The successful development and operation of a new type roll roughing machine which reduces costs and increases rolling mill production over present practice has been announced by American Wheelabrator and Equipment Corporation. This machine employs a standard airless blasting wheel to throw chilled iron abrasive, by centrifugal force and under positive directional control, against the exposed work surface of the mill roll.

The equipment consists of a special cabinet equipped with a standard unit, abrasive circulating and storage equipment, and a special spinner car which supports and rotates the rolls.

In operation the roll to be roughened is loaded onto the spinner car at a loading station adjacent to the cabinet. The car then moves, under its own power, to a position inside the cabinet where the blasting cycle is started by the operator after cabinet doors are closed and auxiliary equipment put in operation.

By the use of limit switch relays, the spinning of the roll, movement of the car and flow of abrasive are controlled to secure an automatic operation, requiring no special skill or judgment on the part of the operator, and which can be identically reproduced time after time. The resulting roughening of the roll is extraordinarily deep and uniform even for the hardest rolls.

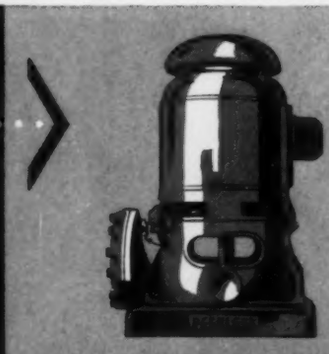
The first machine of this type went into operation recently in the tin plate mills of the Tennessee Coal Iron and Railroad Company in Birmingham, Alabama, and it was found that, as a result of the exceptionally deep etch put on these rolls by the machine, the average service life of the rolls increased 35 per cent over former practice. This equipment is presently dressing five rolls per hour. However, the bulk of the time is consumed in loading and unloading the rolls and moving them into position in the blast chamber. Actual blasting time is only two minutes per roll.

The design lends itself to the blasting of rolls in pairs and, as a result of the operating data indicated by this installation, this change is being incorporated in the design; thereby, doubling the production rate of the machine.

We'll help you engineer the correct pump to your application

VERTICALS

VERTICAL DEEP WELL AND CLOSE-COUPLED TURBINE PUMPS—HYDROFOIL PROPELLER AND MIXED FLOW PUMPS—MINE PUMPS—HI-LIFT PUMPS—UNDERWRITERS' APPROVED VERTICAL FIRE PUMPS—DOMESTIC FIRE SYSTEMS.



PEERLESS VERTICAL TURBINE PUMP

PEERLESS TYPE A HORIZONTAL PUMP

HORIZONTALS

GENERAL PURPOSE PUMPS—BOILER FEED PUMPS—SEWAGE PUMPS—CHEMICAL PUMPS—UNDERWRITERS' APPROVED FIRE PUMPS—REFINERY AND PROCESS PUMPS.

Plan with Peerless

FOR *unbiased* PUMP RECOMMENDATIONS

Peerless manufactures pumps in both vertical and horizontal types for most services in all industries.

Bulletins describing individual applications of each of these types of pumps are available on request.

PEERLESS PUMP DIVISION

FOOD MACHINERY CORPORATION

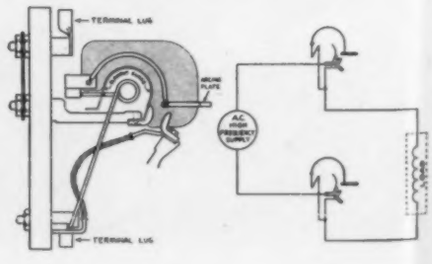
Factories: Los Angeles 31, Calif.; Quincy, Ill.; Indianapolis, Ind. *District Offices:* Chicago 40, 4554 No. Broadway; New York 5, 37 Wall St.; Atlanta Office: Rutland Building, Decatur, Georgia; Dallas 1, Texas; Fresno, Calif.; Los Angeles 31, Calif.

Distributors in all Principal Cities

NEW CONTACTOR LINE FOR HIGH FREQUENCIES

▲ For heating or hardening applications using power of high frequency for the heat-treating or hardening operations, Electric Controller and Manufacturing Company has announced a new line of contactors developed specifically for the closing

The flexible connector to the movable contact is so shaped that the magnetic field directs the arc upward as the contactor opens.



why Okonite continues to use

UP-RIVER FINE PARA RUBBER

for cable insulation

For obtaining rubber insulation of the highest dependability, Okonite researchers and independent authorities, too, remain convinced that only the highest grade natural rubber provides all the needed factors. That's why, in spite of its premium price, Up-river Fine Para rubber is still used by Okonite for insulating wires and cables.

Its long life is proved. Service records over the years establish this beyond question. It possesses greater uniformity, and accumulated data show it gives better aging qualities than plantation or any other type of rubber.

Okonite cannot afford to endanger its customers' best interests by sacrificing the known value of Up-river Fine Para rubber for the lower-cost synthetic rubbers which have no extended service record. Experience has shown that accelerated aging tests, however promising, are not a sound basis for judging the life of products having different components.

Published evidence demonstrates that synthetic rubbers — no matter how well compounded — give inferior results in 2 or more of the following essential characteristics: elongation, tensile strength, insulation resistance, power factor, effect of moisture on electrical properties, consistent and stable electrical values.

Find out more about the steps Okonite engineers are taking to build true value into cables. The selection of rubber is only one of many described in Research Publication IS-101. Address The Okonite Company, Passaic, N. J.

6448

with today's installation costs* only the **Longest-Lived** will be economical

* The lifetime cost of a cable rather than its first cost is the only true measure. Okonite wires and cables, built to stand up better and longer, can offset high installation costs.

OKONITE SINCE 1878 insulated wires and cables

THE BEST CABLE IS YOUR BEST POLICY

and opening of these high frequency power circuits.

Known as the Type LZ of "Line-arc" design, these contactors are of double-pole construction, using one pole to open each side of the line. Their blow-out coils are not subject to excessive heating from eddy currents, but instead, are introduced in the circuit at the time the contactor starts to open to interrupt the flow of current.

One end of the blow-out coil is connected to the arcing-plate, located at the front of the arc shields, and the other end is connected in the conventional manner. At the instant the contacts start to separate, the arc is transferred in about 1/500th second to the circular guard over the blow-out coil to the arcing-plate. The blow-out coil is thus automatically inserted and the arc is extinguished quickly under control of the "Line-arc" principle which allows the ends of the arc to travel in opposite directions, and stretch itself out. The arc does not burn the arc shields, because it follows the form of a line, centered between, but not touching, the arc shields.

The flexible connector to the movable contact is so shaped, that the magnetic field surrounding this connector directs the arc upward to the arcing-plate and blow-out-guard as the contactor opens.

VISIBLE AUTOMATIC OILER REPLACES OIL CUPS

▲ A new, visible, unbreakable, automatic oiler is being manufactured by Trico Fuse Manufacturing Company, to replace ordinary oil cups, specially designed for places where space between oil hole and machinery is very limited. The feed spout is arranged to the side instead of dead center, making it possible to mount the oiler where clearance is as little as ¾ in.

The oiler automatically lubricates solid, wick, or waste-packed bearings. On the slightest temperature rise, the oiler discharges a few drops of oil. As the bearing receives oil, it cools and the feeding stops automatically. This

operation repeats itself constantly and positively without attention. Oil waste, costly down time for frequent hand-oiling, damage to walls and finished merchandise, accident and fire hazards, are eliminated.

The oil supply is always visible and one filling lasts a long time. The reservoir is unbreakable plastic; no cork gaskets to leak; 50 per cent lighter in weight; and all metal parts are bright cadmium-plated for beauty and easy cleaning. Bottle is removable for easy filling.

Made in one, two and four ounce capacities. Installation can be made quickly by removing old oil cup and screwing in a ⅛ in. pipe thread adapter, furnished with every oiler.

HEAVY DUTY CONTACTORS FOR STEEL MILL USE

▲ The latest additions to the Allis-Chalmers Manufacturing Company's line of contactors are 1500, 3000 and 6000 ampere units for operation on up to 750 volts direct current. They are single-pole, heavy-duty, magnetically-operated, frame-mounted, rear-

Picture of Progress

CUPRODIZING installation in a modern wire mill. CUPRODIZING wire prior to drawing means less wear and tear on the dies—improved drawing and greater linear footage of wire per die. Photograph by courtesy of the Buffalo Plant, Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation.

CHEMICALS ACP PROCESSES
RUST PROOFING AND PAINT BONDING
Granodine ®
Durodine ®
Modine ®
Lithoderm ®
Thermit-Granodine ®
RUST REMOVING AND PREVENTING
Deoxidine ®
Pyrolux ®
PICKLING ACID INHIBITORS
Rodine ® ®

WIRE and TUBING PRODUCTION Improved by

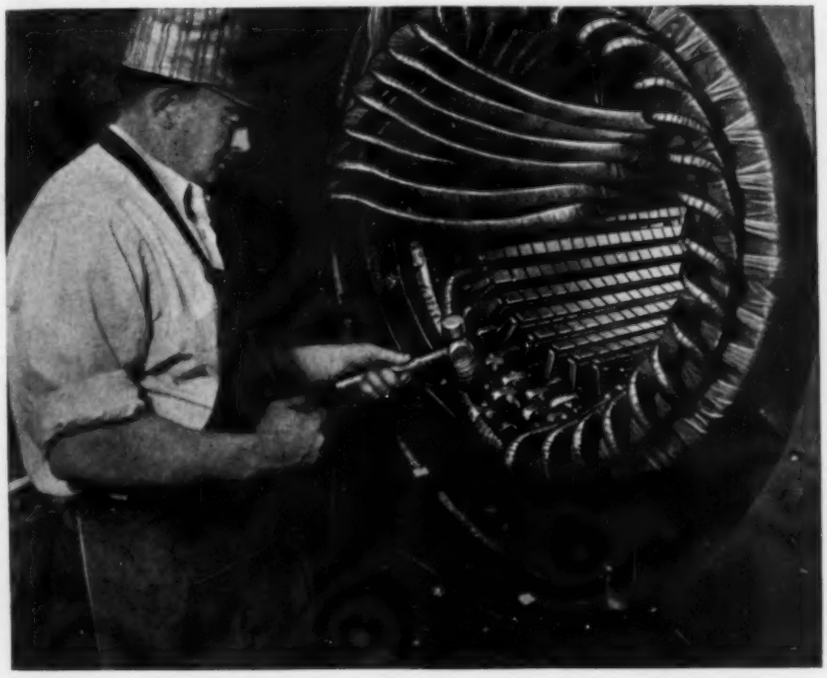
Cuprodine*

"Cuprodine" deposits a thin, adherent layer of copper on steel—that reduces scratching and wear on dies, prolongs die life, and promotes a greater linear footage of drawing per die. It works effectively on Stainless, as well as on carbon steels.

A simple speedy immersion process, without electricity—"Cuprodizing" is the modern, economical answer to your drawing problems.

AMERICAN CHEMICAL PAINT CO.
AMBLER ACP PENNA.

to help you... beat motor heat!



When overwork and ambient heat keep motor temperatures up, burnouts can be a constant threat to operation. To beat motor heat — to prevent frequent motor overhaul — insist on Deltabeston* magnet wire for every winding job.

To help you beat the particular heat conditions your motors have to meet, Deltabeston is built in types for all high-temperature conditions up to 200 C. Made of purified asbestos, firmly bonded to high-conductivity copper, Deltabeston magnet wires are flexible for easy winding, heat- and moisture-resistant for long service. Deltabeston magnet wires are manufactured in all sizes and shapes.

Whether you do your own rewinding or send it to an outside shop, always specify heat-beating Deltabeston magnet wire to beat motor heat.

To help you select

Now, to help you select the proper magnet wires for your heat problem, an informative 20-page booklet is ready for mailing. It contains information on the heat-beating Deltabeston line and a handy selector chart. Just fill out the coupon, and mail it to us for your free copy.

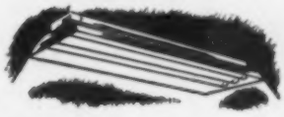
**Trade-mark Reg. U. S. Pat. Off.*

GENERAL ELECTRIC

HI-AMBIENTS

Practical product suggestions from your Deltabeston Distributor

FOR FLEXIBLE LEADS . . . on heavy apparatus that involves hot work, such as electric furnaces, cranes handling hot metals, and the like, Deltabeston motor lead cable, YK-2253, is a popular choice. Insulated with an impregnated wall of felted asbestos and asbestos braid, it resists heat, flame, oil, and corrosive vapors up to 125 C (257 F).



FLUORESCENT FIXTURES . . . need heat-resistant wiring in and around the ballast. For those located in hot, humid places, *all* the wiring should be heat resistant. Why not make your installation with the same type of Deltabeston wire which ballast and fixture manufacturers use?

WIRING JET PLANES . . . may be a long way from your business, but the choice of a Deltabeston aircraft wire for this extra-severe duty helps to explain why so many folks turn to us for solutions to "impossible" insulation requirements.

DELTABESTON

Wires and Cables

built to beat the heat

Section Y6-346
General Electric Company
Bridgeport 2, Connecticut

Please send me the new, free booklet on Deltabeston magnet wires.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

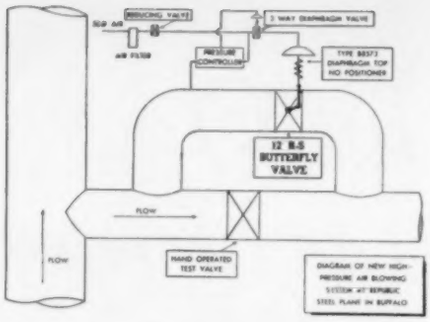
connected contactors with up to eight heavy-duty, normally open or normally closed, double-break auxiliary interlock contacts.

The main contacts are designed with unique arc tips which force the arc out onto the ribs of the arc runners. The arc chute has a divider to help cool the arc. All parts of the contactor, including the main and auxiliary contacts, are readily accessible.

These new contactors are particularly adapted for frequent starting and control of large direct current motors such as are common in steel mill installations.

REPUBLIC STEEL INSTALLS VALVE IN BLOWING SYSTEM

▲ A 12 in. 125 lb R-S Products valve contributes vitally as an air-blast relief in a million dollar high-pressure blowing system at the Republic Steel Corporation's plant in Buffalo, New York. The valve provides air relief to protect the turboblower in the system from excessive pressures.



Production increases of 20 per cent are averaged on new Republic installation.

It is a 125 lb valve with 125 lb American standard flanges. Body and vane are made of "H" metal for resistance to temperatures of 250 to 350 F. The valve is opened and closed by a diaphragm top which in turn is actuated by a pressure controller adjusted to open the valve at 40 psi and close it when pressure drops below 39 psi.

Production increases at the Republic Steel plant have averaged about 20 per cent. This progress is dependent on an extremely high-pressure blowing system, which is in turn dependent on the successful operation of the special valve as a safeguard against excessive pressures.

INDUSTRIAL SAW HAS MULTIPLE CUTTING ACTION

▲ Outstanding improvements have been incorporated in Clipper Manufacturing Company's saw cutting brick, tile, concrete, quarry tile, fire brick, for building construction, as well as for industrial plants and furnace maintenance. Among the new features, are dual belt drive for increased power, snap-on-blade cover, streamlined positions for instant one-man change, and fully adjustable conveyor clamps, both elevating and non-elevating types.

Improvements have been made to provide even greater efficiency, through the use of multiple cutting action, which minimizes the arc of contact and exhausts cut-away particles as soon as they are cut. This allows the blade to cut its own path. The multiple cutting action reduces frictional heat, requires less power and

BIGGER LOADS...MORE TRIPS
The Blaw-Knox line of Heavy-Duty, Four-Rope Buckets includes many specialized designs for fast rehandling of ore, coal, slag, etc.... Capacities up to 25 tons. From the array of buckets listed and illustrated in Catalog No. 2059 you will find the one that fills your requirements exactly. Send for a copy.
BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2040 Farmers Bank Bldg., Pittsburgh 22, Pa.
BLAW-KNOX BUCKETS

Type MT — single pole, electrically operated breaker. Application range: 250 and 750 V. D-C. Interrupting rating is 150,000 Amp. in capacities 2000 and 4000; 250,000 Amp. in capacities 6000 and above.

Only *Switchgear Specialists* can give your vital equipment protection like this . . .

I-T-E Type MT Automatic Reclosing Air Circuit Breaker *(for Pedestal mounting)*

Short circuits and overcurrents in the power distribution systems of steel mills and electrolytic plants can wreak havoc on vital equipment. Rolling mill generators, motors, rectifiers, heavy-current feeders, and synchronous converters are easily damaged and expensive to replace. Production shutdowns for repairs can be costly.

With these facts in mind, I-T-E—*specialists in quality switchgear*—designed and built the Type MT Automatic Reclosing Circuit Breaker—a unit of dependable, full-time protection for heavy-capacity equipment. The quick-acting MT interrupts extremely heavy direct-currents in about 1¾ cycles (60 cycle basis) at 25% to 100% of interrupting rating; clears shorts rapidly, dependably.

The I-T-E *Rate-of-Current-Rise Trip* anticipates extremely high currents. It distinguishes between a useful load of high value and a dangerous fault current, and trips the breaker before the danger peak is reached, preventing possible damage to cables and equipment.

Electrically and mechanically trip-free on overcurrent, the MT trips immediately when closed on a fault. All tripping devices are direct-acting and instantaneous. A specially designed, self-energizing buffer mechanism smoothly absorbs shocks of opening—prevents sticking or bouncing. Magnetic blow-out coil and arc extinguisher provide for rapid, safe extinction of arcs under all current conditions.

The MT is normally built in two styles: pedestal mounted, and panel mounted. Pantograph drawout, and truck mountings can also be furnished when required. Each style has the same sturdy frame of hot-rolled steel, formed and welded into a rugged, protective support unit.

Complete details on the I-T-E Type MT Automatic Reclosing Air Circuit Breaker are contained in illustrated catalog 2201. Send for your copy. *The I-T-E representative in your locality will be glad to advise you on applying the MT—and other I-T-E protective equipment—to your electrical distribution system. Use his services with no obligation.* I-T-E Circuit Breaker Company, 19th & Hamilton Streets, Philadelphia 30, Pa.

31 OFFICES IN UNITED STATES AND CANADA

I-T-E

MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS HIGH SPEED CIRCUIT BREAKERS

keeps the blade sharp for faster cutting and longer blade life.

The design makes it easy to cut the most intricate shapes without stopping for adjustments. The new dustless masonry saw has been designated as the HD-48. One reported advantage of the new model is the fact that it will cut with amazing speed and ease regardless of whether used "wet" or "dry."

When working in closely confined areas, by turning on the circulating system dust is immediately and completely eliminated. Water is circulated from the reservoir, which is an integral part of the frame, by means of a pump mounted on the cutting head. A stabilizer control is provided to permit exact depth scoring. This new model, like all Clippers, is completely portable.

New blade specifications have also been announced. Among these is a blade for cutting extremely hard materials "dry," together with a complete series of specifications for "wet-cutting," including bonded diamond blades for tile, glass, marble, porcelain, etc.

SYNTHETIC WAX FOR METAL DRY DRAWING

▲ Pilot plant and production scale tests with a new synthetic wax as a lubricant for dry drawing high carbon steels have proved more efficient and economical than older methods.

This wax, Acrawax C, alone or in conjunction with other common ingredients markedly reduces friction and heat, decreasing scratching and wire breakage. Considerable increase in drawing speeds, longer die life and improved surface of the steel are results reported from its use in direct comparison with other commercial lubricants.

Acrawax C, a wholly organic synthetic wax manufactured by Glyco Products Company, Inc., is a new approach in lubrication differing greatly from the accepted dry drawing lubricants. It is a heat-stable material of very high melting point (140–142 C or 284–288 F).

The wax is currently being used successfully in some of the largest mills for dry drawing high carbon steel wire rope, spring wire and tire bead wire. It is also being adopted as a lubricant for drawing bars and rods, odd shapes as well as round shapes, of high carbon and alloy steels. Its use as a lubricant in drawing cold heading stock is of long standing.

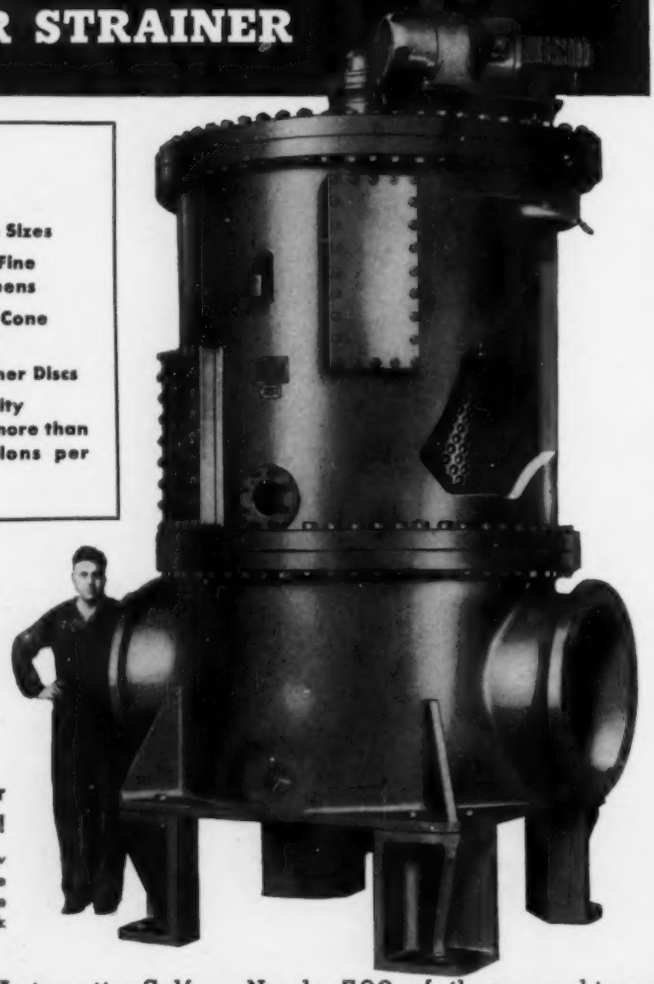
VALVE INTRODUCED FOR HOISTING USE

▲ A new 3-way, neutral position hand operated valve, the 1291-N3, has just been introduced by C. B. Hunt and Son, Inc.

These valves are compact, — and are of strong, dependable, trouble-free

BRASSERT SELF-CLEANING WATER STRAINER

- Automatic
- Self-Cleaning
- 3" to 30" Pipe Sizes
- Stainless Steel Fine Mesh Cone Screens
- Bronze Slotted Cone Strainer Media
- Porcelain Strainer Discs
- Installed Capacity Now cleaning more than 4 million gallons per minute



New Strainer Media !

The New Bronze slotted cones have large free area, are easily back washed.

The Brassert Automatic Self-Cleaning Strainer removes fine suspended particles from raw or process water and disposes of it in a continuous process. Available in ten inlet sizes from 3" to 30".

Nearly 500 of these machines are currently providing a steady flow of clean water, from such sources as sea, rivers, lakes, and wells to a large number of industrial plants.

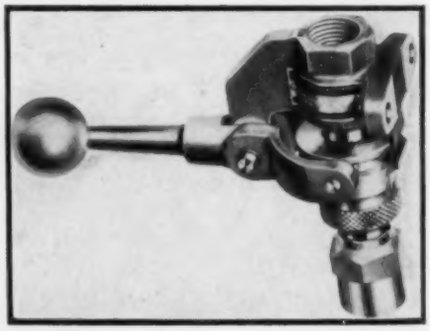
Write for descriptive circular No. K-1

S. P. KINNEY ENGINEERS, Inc.

233 OLIVER AVENUE

PITTSBURGH 22 • PENNSYLVANIA

These valves are designed for use with single acting air cylinders.



LINK-BELT Ball and Roller Bearings

The Link-Belt Line of Self-Aligning Ball and Roller Bearings is *complete*, and you will have no difficulty in selecting the proper bearing in mounted and unmounted types (from Books 2094, 2095 and 2196 sent upon request) for all general industrial use. For use of ball and roller bearings as an integral part of machine design and construction, we invite you to discuss your problems with our engineers.

LINK-BELT COMPANY

Indianapolis 6, Chicago 9, Philadelphia 40, Pittsburgh 19, Atlanta, Dallas, Cleveland 13, Minneapolis 5, San Francisco 24, Houston 2, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities. 10,943

construction. They have a forged bronze handle, a brass sleeve, a stainless steel body, stainless steel adapter, and a forged bronze head that is fitted with a flat spring that indexes and holds the handle mib in "On," "Off," and "Hold" or "Neutral" position.

These valves are designed for use with single acting air cylinders, and, due to their ability to index and hold the handle in neutral or hold position, are especially recommended for use with hoists or other applications when it is desired to raise, lower, and hold the load in an intermediate position. Furnished in ⅜ and ½ in. pipe sizes for air pressures up to 250 psi.

MACKINTOSH-HEMPHILL INCREASES ROLL CAPACITY

▲Mackintosh-Hemphill Company has announced a $75,000 improvement project for its Midland, Pennsylvania plant. In order to increase production of steel mill rolls, the company has placed an order for two specially designed automatic lathes. These lathes will machine finish, ready for mill installation, steel backup rolls for continuous strip mills, as well as slabbing and cogging mill steel rolls for blooming mills.

This first 1948 order for improved plant equipment has been given to the machinery division of Mackintosh-Hemphill Company, which will construct the lathes at the Pittsburgh South Side plant on Bingham Street.

No other one instrument

PERFORMS ALL THESE FUNCTIONS

INDICATE AIRFLOW

INDICATE FUEL FLOW

SHOW RATIO OF AIRFLOW and FUEL FLOW

The Hays Visio-Ratio Gage is unique among indicating instruments because it performs the functions of three indicators—air-flow, fuel-flow and ratio.

Illustrated is a Visio-Ratio Gage which measures the flow of gas to a gas fired industrial furnace and the flow of air used for the combustion of the gas. Both these scales are calibrated in rate of flow in 1000 cu. ft. per hour.

The center scale is calibrated to show the percentage of excess of deficiency of air used to burn the gas with a range of 30% deficiency to 50% excess.

The spot at which the pointers cross over the center scale indicates directly the percentage of excess of deficiency of air used for combustion, eliminating the mathematical calculations which otherwise would be required with each change in flow of gas or air. The ratio used depends on the type of flame desired—oxidizing or reducing.

The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA U.S.A.

AIEE INTRODUCES NEW STANDARDS

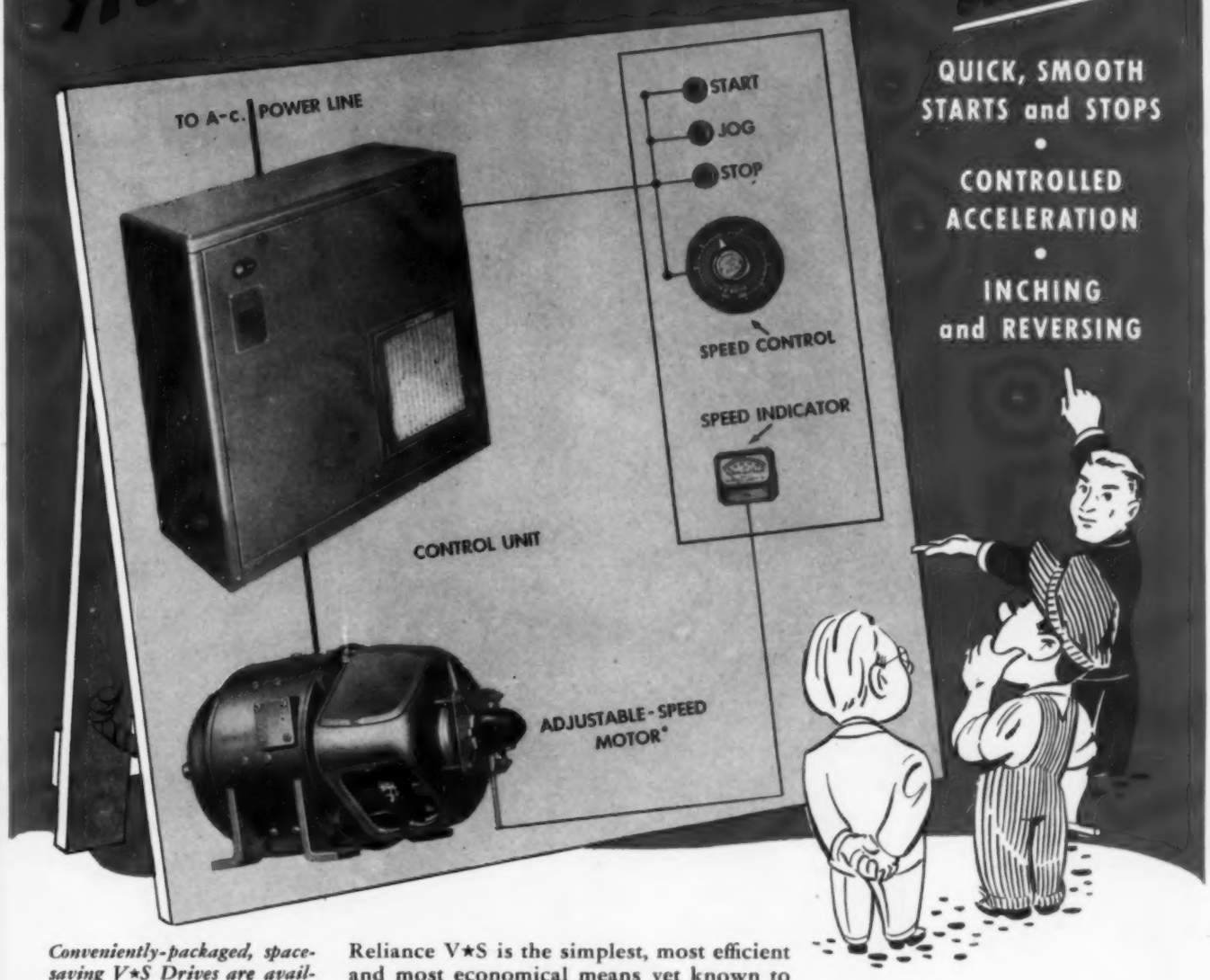
▲ The Standards Committee of the AIEE has just issued two new standards: No. 48, "Standard for potheads" (Including Test Code) (January 15, 1948). No. 49, "Standard for Roof, Floor and Wall Bushings" (Including Test Code) (January 15, 1948).

These two standards were approved by the Standards Committee on October 22, 1947, and by the Board of Directors on November 5, 1947. Copies may be obtained from AIEE, 33 West 39th Street, New York, New York.

HOMESTEAD VALVE OPENS NEW CORAOPOLIS PLANT

Climax of a $400,000 postwar expansion program was marked February 20 when Homestead Valve Manufacturing Company formally began production of "Hypressure Jenny" steam cleaners in its new Coraopolis plant. Modern and up-to-the-minute in every detail and construction, the new plant has over a thousand feet of conveyors as well as a motorized assembly line. Incoming materials flow from the freight cars and trucks right into the production and assembly lines with a minimum of handling.

ADJUSTABLE SPEEDS from A-c. Circuits and:



Conveniently-packaged, space-saving V★S Drives are available from 1 to 200 hp.

**Two or more motors may be operated simultaneously from a single Control Unit.*

RELIANCE V★S DRIVE

Reliance V★S is the simplest, most efficient and most economical means yet known to industry of providing *Adjustable speeds from A-c. Circuits.* And it's *All-electric!* V★S offers many operating features, including an infinite range of stepless speed changes—inching for close inspection—controlled acceleration and deceleration—maintenance of proper tension for roll-fed materials—reversal at any point desired. All V★S functions can be controlled automatically or manually, at the machine or from remote stations. For unlimited flexibility of machine operation—with savings that quickly pay for the installation—investigate V★S today. Write for Bulletin 311.

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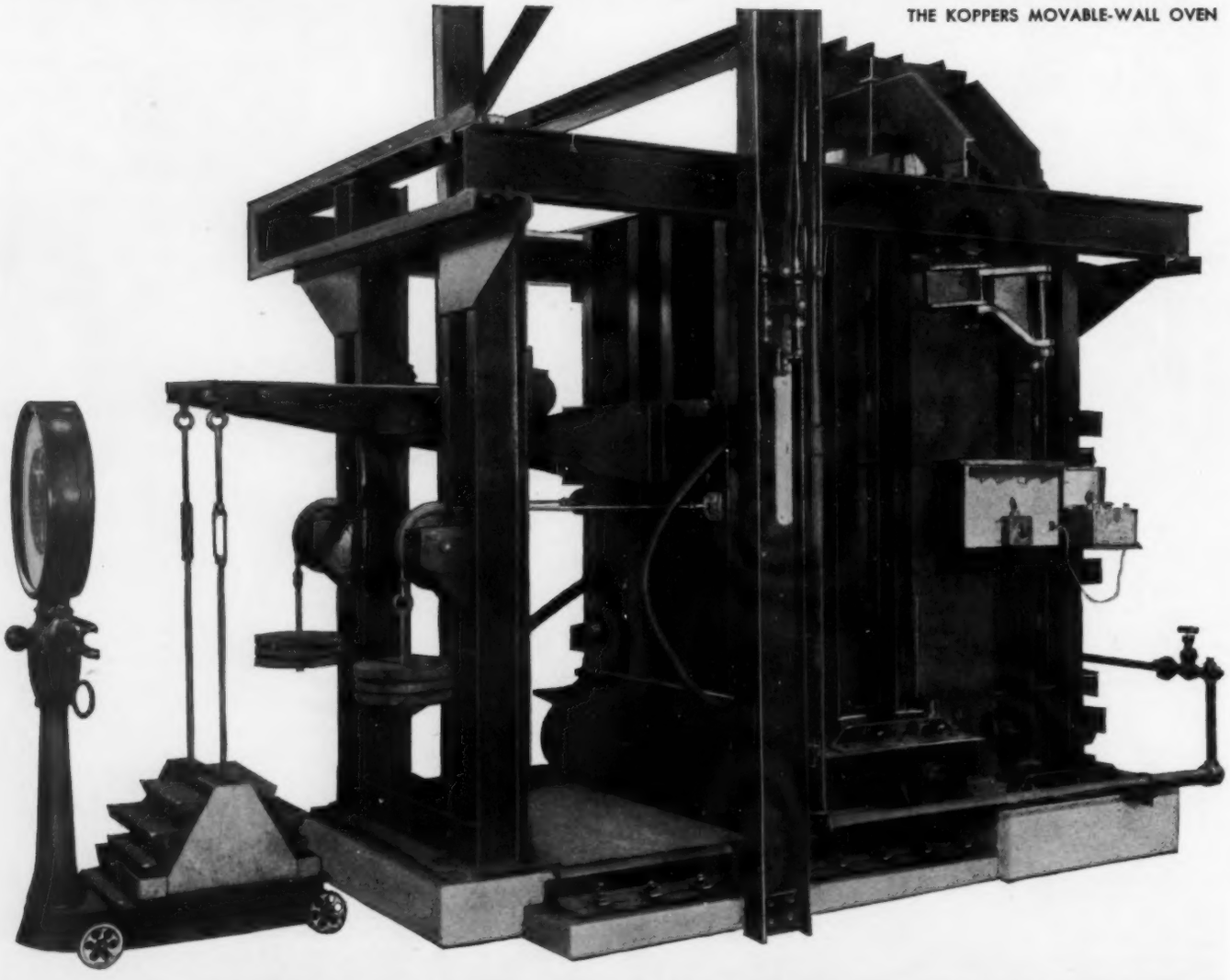

THE KOPPERS MOVABLE-WALL OVEN

TO DETERMINE THE EXPANSION FORCES OF YOUR COALS

Because of the present necessity of using many coals, possibly of different ranks, for the production of metallurgical coke, it is now more than ever imperative for the operators of byproduct coke-oven plants to know that the coal mixes charged into their ovens will not exert dangerous expansion-pressure during carbonization.

Koppers Research Department has developed the Koppers Movable-Wall Oven, by means of which a large background of data has been accumulated on the expansion forces exerted by various coals and mixes of coals.

In addition the Koppers Movable-Wall Oven will provide coke comparable to that made in full-scale byproduct coke ovens for chemical and physical quality tests.

A monograph on "The Selection of Coals for the Manufacture of Coke" by Mr. C. C. Russell is available for your further information.

We are prepared to furnish Movable-Wall Ovens to the industry and we believe that they should be a useful adjunct to every byproduct coke-oven plant.

KOPPERS COMPANY, INC.

ENGINEERING & CONSTRUCTION DIVISION

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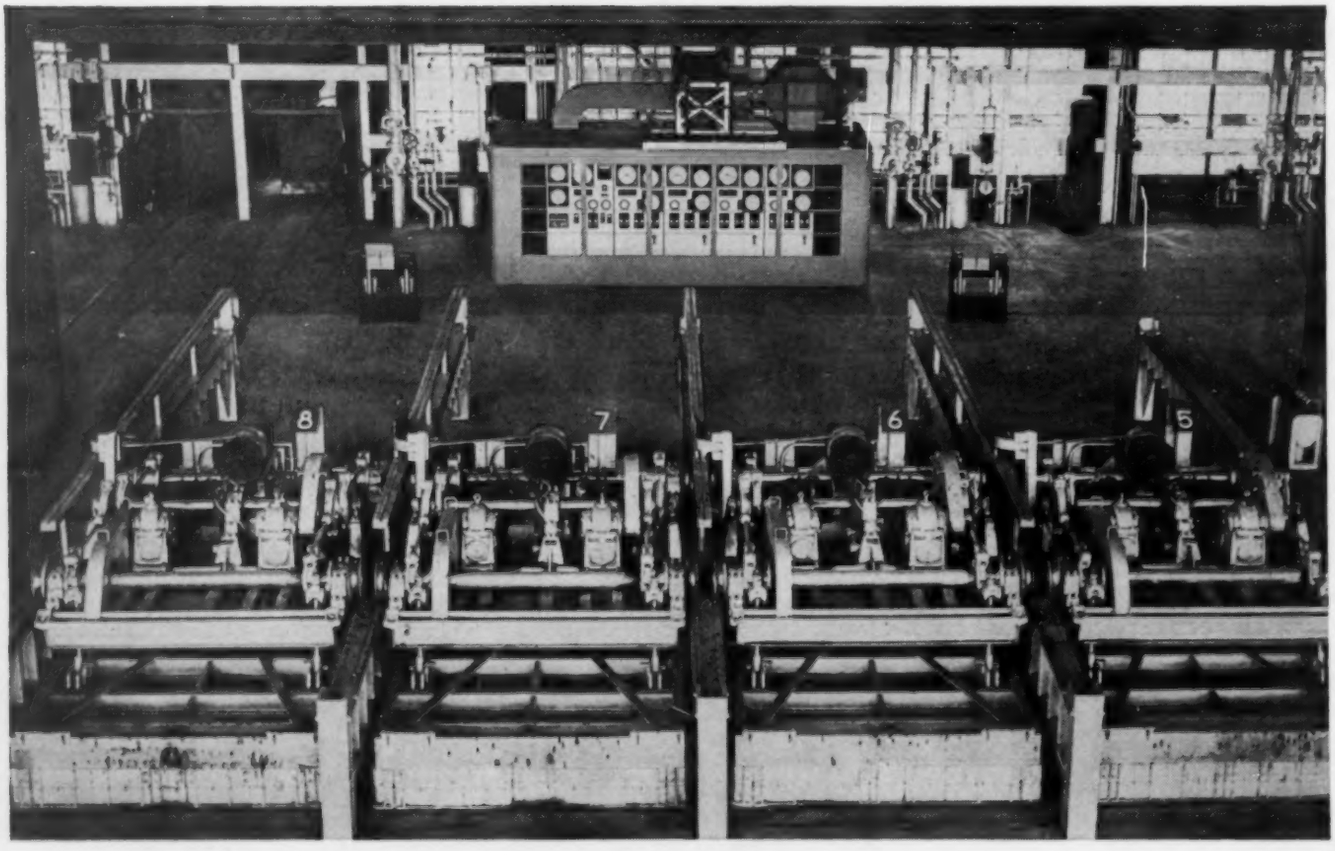
these year-old soaking pits have Hagan air-operated controls

A little over a year ago a major steel company began regular operation of a new mixing station and 16 new soaking pits. At the time this was the largest such installation in which Hagan Air-Operated Controls were used.

The fuel in these pits is a mixture of blast furnace and coke oven gas, but the system automatically swings to straight coke oven gas when the supply of blast furnace gas is low. Oil can be used when desired, and as far as controls are concerned, the change from gas to oil requires only the switching of a measuring circuit.

The year's experience has fully confirmed the advantages which originally led to the selection of Hagan *Air Operated* Controls. These controls have proved to be cleaner, faster, safer and more dependable.

Hagan Air-Operated Controls can be used with either old or new installations. Our engineers will be glad to give you full information.



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Heppenstall rotary slitter and trimming knives are establishing high performance records wherever strip steel is cut. These knives remain in service longer because they fulfill the rigid Heppenstall requirements of quality in the base metal *plus* quality of workmanship.

To assure the utmost in quality, Heppenstall's Electric Induction Steels are specified and held to the closest ranges of chemical composition . . . thus yielding a clean, sound, homogenous base metal. The Heppenstall operations of forging, annealing, machining, heat treating, and grinding are then performed with meticulous care. The end result: the finest knives obtainable.

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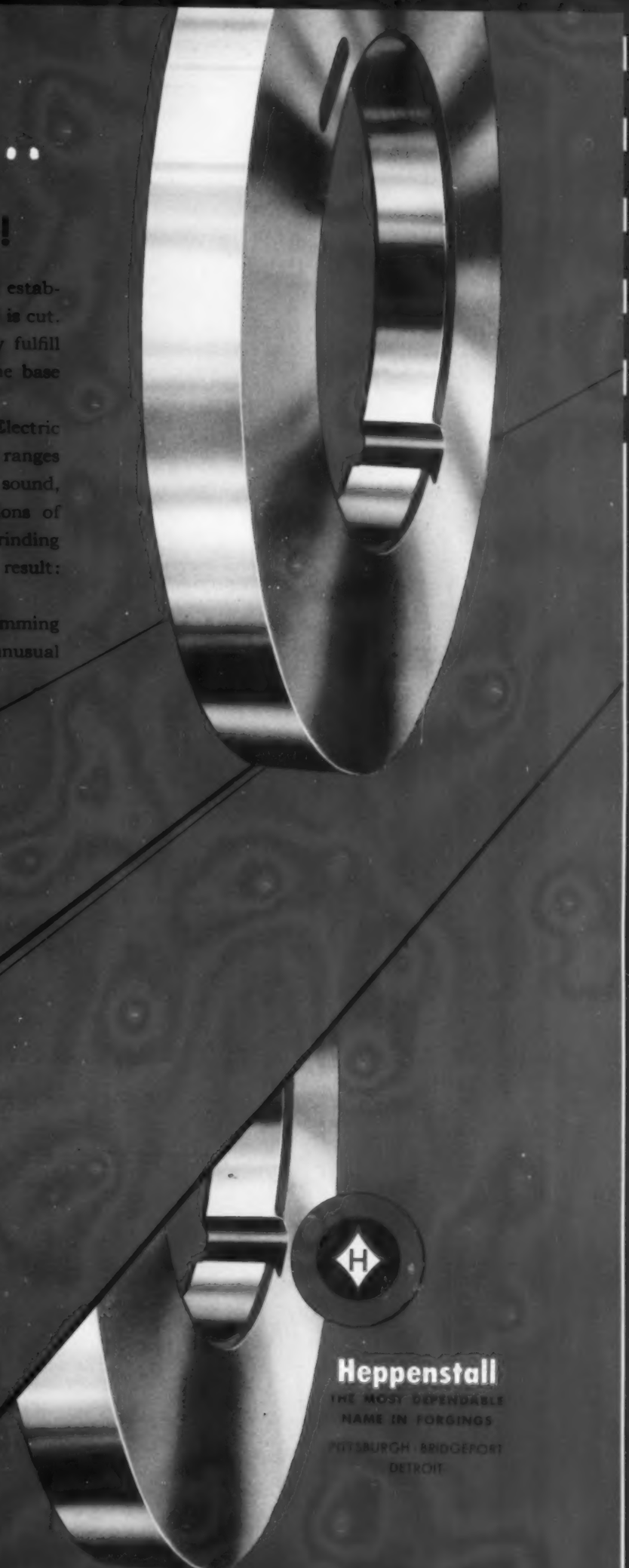

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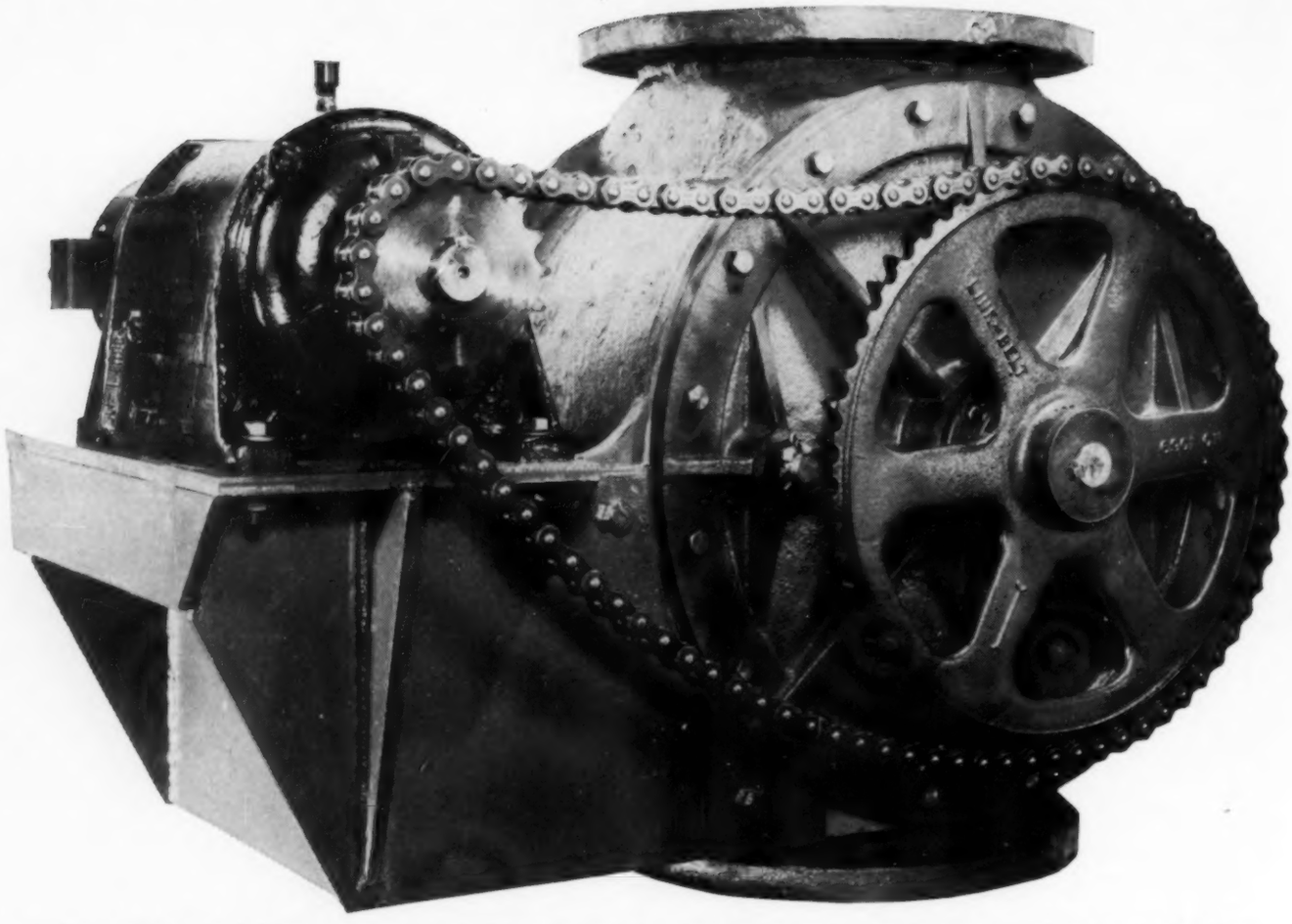

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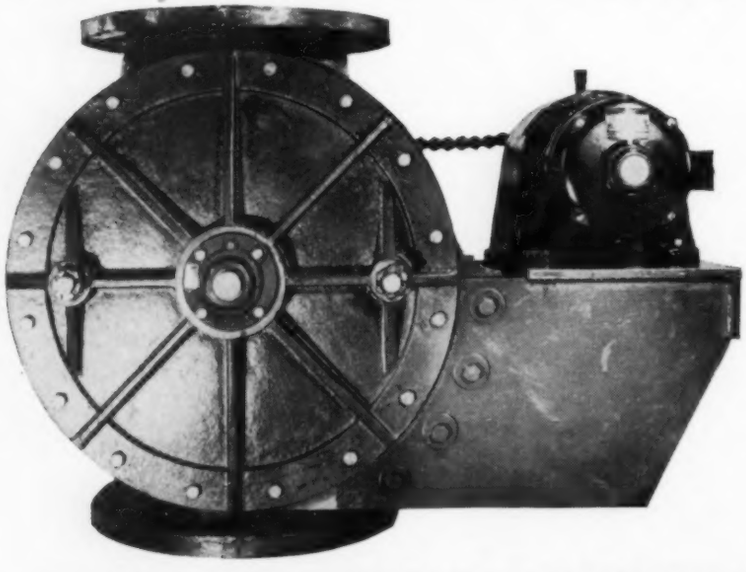

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MARCH, 1948

(1) Acid-Proof Cement

A data chart with indexed prices is available listing over twenty of many technical cements for acid-proof construction, electrical insulation, sealing, assembling and pipe jointing. It gives application data, technical characteristics, weights and prices of cements, shipping containers and other detailed information. Sauereisen Cements Company.

(2) "Leveltronic"

Just published is a completely detailed catalog and price sheet on a new "Leveltronic" relay, designed for basic applications in the control of liquid level, interface, pressure, and temperature. This relay is a new improved electronic circuit using hot cathode thyratron control. (27). R-S Products Corporation.

(3) Lifting Hoist

The "Zip-Lift," a fast, lightweight, inexpensive accessory tool, is now offered in 250 lb capacity according to a new bulletin. This new hoist features a genuine wire rope — providing a smooth hoisting service. It is especially applicable when comparatively light and fixed loads up to 250 lb are handled frequently, and where a relatively fast speed is preferred. In addition to its wire rope, the new lift has many other features which you would not ordinarily expect on a hoist in the low-price field. It has pushbutton control, crane-type limit switch, double brakes, transformer equipped where line voltage exceeds 110 volts so operator handles only 110 at pushbutton — all quality features usually associated only with the most expensive hoisting equipment. (H-20-3). Harnischfeger Corporation.

(4) Magnetic Laboratory

Just issued is a bulletin which describes operation of a laboratory for solving separation problems in many industries. Purpose of the laboratory, whose service is free, is to analyze materials to determine if, and how best, they can be magnetically separated and to develop new and improved separators. Procedure to be followed in arranging for product tests is described. (1120). Dings Magnetic Separator Company.

(5) Truck Tractors

In a new 40-page catalog just introduced a full line of machines and special handling attachments is presented. Prominently featured are: the Clark "Pul-Pac," which handles unit loads based on sheets of corrugated paper, fiber board or similar material; and the Clark "Hi-Lo-Stack" which combines 130-in. lift, 83-in. overall height and 62-in. "free" lift. (TC-7). Tructractor division, Clark Equipment Company.

(6) Meehanite Castings

As part of a long range research aimed toward the development of material to aid machine and structural designers, a new bulletin entitled "Formulas for Computing Maximum Stresses and Deflection in Circular Flat Plates," has just been published. The book contains 18 pages of tables, charts and formulas evolved and simplified for direct application to constructions utilizing the characteristics of Meehanite castings. (26). Meehanite Metals Corporation.

(7) Flexible Couplings

Flexible couplings are the subject of a 20-page catalog now being distributed. The catalog contains illustrated and descriptive information concerning the various types in which this coupling is offered, as well as a complete table on gear coupling ratings. Illustrations are included depicting typical coupling installations. (57). John Waldron Corporation.

(8) Metallizing Gun

Only ten cu ft of air per minute for metallizing. This, the outstanding feature, is just one of many new features of the new "Light Duty—Low Air" metallizing gun just announced in a new bulletin. This new gun also has new turbine construction requiring only one-third the power, making a large compressor unnecessary. The new nozzle construction assures lower cost per pound of metal sprayed because of the low consumption of acetylene and oxygen. And yet another feature — turbine control which requires only one adjustment for the entire range of metallizing wires. The gun weighs only 4 lb 2 oz, considerably lighter than other metallizing guns. (55). Metallizing Engineering Company, Inc.

(9) Wire Rope

A new 56-page booklet "Life-Line," shows the various processes of manufacturing wire rope from wire rods through wire and rope mills. The story is presented in pictures with short captions in a similar manner to a strip film. MacWhyte Company.

(10) Operation Recorder

The operation recorder is probably the most versatile recorder of its kind on the market. Although the operation recorder is not a new product, industry's desire for higher productivity and more automatic operation has created a new interest in the instrument. Bulletin 247 contains a factual and straight-forward description of the operation recorder, its design features, methods of installation and applications. This bulletin tells how to select these recorders. The recorders will record, time of occurrence, sequence, and duration of a multiplicity of events. (247). Esterline-Angus Company, Inc.

(11) Handling of Materials

A new catalog illustrates and describes all Mercury equipment and features, in-

cluding the newest additions to an expanded material handling line. Complete specifications and applications are given on fork trucks, lift trucks, tractors and trailers. In addition, special attention is given to a fork truck trackless train system of material handling. (7-11). Mercury Manufacturing Company.

(12) Microphotometer

A reprint is available describing a new microphotometer which enables open hearth and electric furnace helpers to bring the analysis of each melt closely to specifications. The total time per heat is reduced through the use of this new instrument. Samples from electric furnaces and open hearths are sped by pneumatic tube to the laboratory, where exposures are taken, developed and sent to the microphotometer room. An operator next measures densities of preselected spectrum lines with the microphotometer. Another operator translates density ratios into percentage elements, and the foreman then examines the analysis and sends it by Telautograph to the open hearth shop. (Reprint E-90-1) Leeds & Northrup Company

(13) Materials Handling

A copy of "Ironclad Topics" is available to you. This periodical covers latest developments in material handling and shows actual case histories. The Electric Storage Battery Company.

(14) Totally-Enclosed Motors

Literature is available for both a-c and d-c totally-enclosed motors. These publications describe how ventilation that licks the heat problem is provided by air drawn through end bracket and directed by baffles through streamlined passages. Thirteen-point winding treatment includes six special steps to assure the most effective insulation possible. A special bearing design protects these motors indefinitely and eliminates all lubrication worries. (C-125 and C-218). Reliance Electric & Engineering Company.

(15) New Control Principle

An exclusive control principle is described in a catalog which is available to you. This new Jet Pipe principle converts the most delicate pressures or signals into rate of movement of a hydraulic cylinder. It consists of the Jet Pipe swinging freely on a hollow vertical pivot into which oil is pumped at high pressure. As the oil stream leaves the nozzle of the Jet Pipe it strikes at two closely adjacent distributor openings. The openings are piped to both ends of the cylinder which is connected to valve, damper or other type control. The slightest change in the signal moves the Jet Pipe, causing more or less oil to enter the right or left opening. This causes the cylinder to move either to the right or left to correct for the signal variation. As soon as equilibrium is established, the Jet Pipe returns to its median position. For the tough control job where accuracy is a necessity and where valves, dampers, or other mechanisms must be moved, this new Jet Pipe Control is the solution. (139). Askania Regulator Company.

(16) Lifting Magnet

A bulletin is available describing an all-welded lifting magnet which picks up production in steel mill service. Welded, instead of bolted, construction eliminates bolt recesses, allows better proportion of coil space and results in a more effective, permanent, magnetic path. (900). The Electric Controller & Manufacturing Company.

(17) Shock Demonstration

This is not a catalog. If you would like to have a popular demonstration of a torch for cutting stainless steels, simply circle the above number. This new cutting torch brings economical manual flame cutting of stainless steels within the scope of all types of mill operations. It makes it as easy to cut stainless as mild steel. The new torch uses the Flux-Injection principle. This stainless steel cutting method feeds flux from a Flux Feeder Unit into the cutting oxygen stream. Thus, the flux is continuously and evenly dispersed throughout the entire cutting operation. The unit is portable, even when fully charged, so rapid movement from job to job is assured. We repeat, this is a demonstration, not a catalog. Air Reduction Sales Company.

(18) Floodlights

A catalog giving complete information on floodlight equipment is available. These floodlights are designed and constructed to withstand the most severe operating conditions. They are constructed of rugged cast aluminum housed with tight sealing doors and door glass joints, positively dust proof and moisture proof, which give maximum protection to reflectors and lamps and reduces cleaning and maintenance to a minimum. (2100). Pyle-National Company.

(19) Buckets

A new catalog on covering hundreds of buckets is available to you. This catalog lists factors to be considered in the selection of the right bucket and illustrates typical methods of installation. If you have a bucket problem, you should have this catalog. (2002). Blaw-Knox Division of Blaw-Knox Company.

(20) Transformers

"4 Minutes with Pennsylvania Transformers" and "Ask for Askarel" are two 8-page booklets available to you for the asking. If you use transformers, we would suggest that you have these catalogs in your file. Pennsylvania Transformer Company.

(21) Circuit Breakers

Electrical disturbances in your power distribution systems hit you where it hurts most — right in the heart of your production. You can protect your essential production equipment from the hazards of electrical disturbances with an automatic, reclosing circuit breaker. Complete details on this circuit breaker are contained in a new illustrated catalog. (2201). I-T-E Circuit Breaker Company.

(22) Carbon Mold Plugs

"Carbon Mold Plugs," a reprint of an article which appeared in a recent issue of a trade magazine, is available to you. This article told how Timken used 45,000 carbon mold plugs and found that these products are never out-of-round and are constantly accurate in dimensions. These products are structurally strong and may be handled without damage. They can be hammered into place in the mold opening without being crushed. Their use has eliminated 90 per cent of the leakers. The products do not spall. Elimination of burn-outs in the plug holes has improved mold life by 10 per cent. National Carbon Company, Inc.

(23) Fuses

A booklet is available giving features, sizes and details of "Hi-lag" fuses. These fuses have the strongest, most rigid knife blade assembly ever designed in fuses. The two heavy fiber bridges are supported by sturdy brass brackets which add greatly to the strength of the assembly. These bridge supporting brackets are attached to the copper knife blades and contact the entire end of links so that current flows through the brackets as well as the blades over a large area. (4460). Ware Brothers.

(24) Lubrication

Up-to-the-minute information on the care and maintenance of ball and roller bearings is contained in a bulletin available to you. Included are special notes on lubricant application; illustrated copy on storage and handling of lubricants; and a check list of "Do's" and "Don'ts." (506-AIS). New York and New Jersey Lubricant Company.

(25) Herringbone Reducers

A 128-page catalog on herringbone reducers is available. This booklet shows a vast amount of data referring to Herringbone Reduction Units. Illustrations show a broad range of reducer applications and the technical information shows how to select reducers for all conditions of service in accordance with recommended practice. W. A. Jones Foundry & Machine Company.

(26) Research Bulletin

A 32-page research bulletin is available describing what goes into a cable to make it do a better job, what tests it must pass, what care is taken to control its electrical characteristics. With costs as high as they are, choosing a cable is more important than ever. No one can afford a cable unless it protects against unnecessary repairs, against removal and against replacement. (101). Okonite Company.

(27) Mill Motor

Now you can get a d-c mill motor, the MD-600, with more horsepower in the same AISE frame size. For example, a 25 horsepower motor is now available in the No. 6 frame where formerly No. 8 frame was required. AISE mounting dimensions and safety factors remain unchanged. You simply get a lighter, smaller motor with

all the efficiency and power of the next highest frame size. All of this is described in a bulletin available to you. (GEA-4654). General Electric Company.

(28) Burners

A bulletin is available on covering a combination portioning oil and gas burner for automatic control. The bulletin describes how one control lever regulates and proportions the flow of air through the burner and at the same time the flow of oil or gas, or both fuels when so adjusted. Once burners are adjusted for burning either oil or gas, the change from oil to gas or vice versa can be made quickly by merely closing one fuel shut-off valve and opening the other, without piping changes. (407S) Hauck Manufacturing Company.

(29) Inhibitor

A technical data sheet is available on "Rodine," a selective inhibitor, which has revolutionized the pickling of steel. Until this inhibitor was developed the inefficiency of steel pickling was accepted as a necessary evil. Much more acid was used in dissolving metal than was needed in attacking the sub-scale and blowing off the scale. The acid fumes rising from the bath were injurious to workers and corrosive to the steel structure of the pickling house. The pickled steel became acid-brittle and blistered. Production was hampered by this costly lack of control in the cleaning house. This new inhibitor has made precision control possible. Added to the pickling baths, it will reduce the acid's attack on good metal without diminishing its ability to remove scale. (TDS-13-1). American Chemical Paint Company.

(30) Technical Paper

"Some Properties of Low Carbon 8½ Per Cent Nickel Steel." The increasing use of sub-zero temperatures in many industries and the advantages of storing gases in the liquefied state have stimulated much interest in the developments of the materials resistant to brittle behavior at low temperatures. These needs resulted in the development of a low carbon steel which is the subject of this technical paper. (TSDS 13-1). The International Nickel Company, Inc.

(31) Welding Products

A booklet is available on welding products for reclamation and hard-facing. The experience gained in the development and application of manganese steel has enabled this company to develop welding mat erials designed to conserve and protect wearing parts. The material contained in this book will define those applications which have been field tested and processed. Descript ve information of hard-facing and build-upl rods and electrodes, and weldments is included. (1047-W). American Manganese Steel Division of American Brake Shoe Company.

(32) Roll Forming

If you are interested in roll forming machinery, there is available to you a complete and concise booklet of cut-off machines, slitting machines, edge conditioning and straightening machines, stock holders, bulldozers and bending machines. The booklet is reprinted with photographs of applications and tabular information giving many details in which you will be interested. Tishken Products Company.

(33) Chemical Cleaning

"Chemical Removal of Scale from Water Lines," is the title of an article which has been reprinted from SOUTHERN POWER AND INDUSTRY, November, 1947. This technical article tells how scale, sludge, clay, and other objectionable materials coating the inside of water pipe can be easily, cheaply, and safely removed by using chemical cleaning methods. Dowell, Inc.

(34) Roll Grinding

"Reconditioning Hot Mill Rolls" is the title of a new technical bulletin which is available. The bulletin tells how hot mill regrinds and is of special interest to steel mill men. If you use roll grinding wheels, be sure to send for this valuable bulletin. Simonds Abrasive Company.

(35) Crane Controls

A booklet is available on "Magnetorque" crane control which eliminates mechanical load brake. This new control is a revolutionary new principle for a-c cranes. This new unit consists of a simple, indestructable rotor and a stationary field member through which braking forces are exerted electromagnetically. The unit compels the hoist motor to work efficiently under all load conditions. It permits a-c control in many types of crane service where d-c was formerly required. (C-39). Harnischfeger Corporation.

(36) Steam Cleaner

Literature is available on the new "Hypressure Jenny," an instantaneous steam cleaner for a thousand and one industrial uses. This new cleaner is the fastest, most powerful steam cleaner because it produces in less than a minute from a cold start, a steam vapor spray having the right amounts of steam, highly atomized hot water, pressure aid cleaning compound to do a thorough cleaning job. The powerful cleaning spray dissolves, cuts, and flushes grease and dirt from surfaces almost instantly. Hypressure Jenny Division, Homestead Valve Manufacturing Company.

(37) Asbestos Gaskets

Catalogs are available to you on asbestos sheets and gaskets. This new catalog is homogenous in construction and dependable wherever a gasket is required. Every square inch of sheet has a uniform density, thickness and asbestos distribution. Exhaustive tests have shown that this gasket material is suitable for all the temperature-pressure combinations developed in connection with oil and all refrigerants, as well as steam, water, gasoline, ammonia, acids, alkalies and volatile vapors. (115B). Durabla Manufacturing Company.

(38) Threadless Fittings

A catalog is available to you describing a threadless malleable fitting. These fittings are applicable wherever 150 lb, standard weight, black, malleable, screwed fittings are now used. These fittings are the first tested, standard weight, malleable fittings ever to be sold from stock. They are lighter in weight than the same size and kind of threaded fittings due to the absence of the chamber. They have the same wall thickness and center to end dimensions as standard malleable fittings, and can be used with thin wall pipe. Stanley G. Flagg & Company, Inc.

(39) Iron Castings

A catalog is available entitled, "Process-Iron Castings that Solve Your Problems."

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The booklet includes a description on operating control from patterns to castings, metal characteristics, pouring the mold, heavy castings, production machines, small castings, and a table on process-iron characteristics. Other technical information is also included. McNally Pittsburg Manufacturing Corporation.

(40) Refractory Bricks

An excellent booklet is available describing refractory bricks that are electric furnace fused. The booklet contains many illustrations, sketches, cross-section views and charts and curves. There is a section on boiler furnaces and a section on gas generators. (862-SP). Norton Company.

(41) Blowers and Fans

Three booklets are available to you: (1) wall fans; engineering data; (2) propeller fan wheels, and (3) turbine pressure blower; engineering data. All of these catalogs are complete with illustrations of various types of fans and blowers with specifications, constructional data and other technical information. Robinson Ventilating Company.

(42) Flexible Couplings

A catalog on "Flexible Couplings," their value and many advantages, is available to you. This catalog contains valuable information pertaining to flexible couplings, important data and information that has not yet been presented in catalogs of this material. This 124-page book will be a valuable reference book to all users of flexible couplings and engineers who specify such equipment. (44). Poole Foundry and Machine Company.

(43) Volumatic

A folder is available introducing new simplicity and convenience in the production of direct line prints. This folder covers a new printer-developer which provides complete, large-volume reproduction facilities in one simple, compact machine requiring only one operator. A complete departure from conventional design, the Volumatic exposes and develops automatically — and in seconds. (a1041). Charles Bruning Company.

(44) Fluid Drive

A booklet is available on electric motor fluid power transmission. It tells what happens when a fluid drive is interposed between a motor and its load. It also describes what happens when you check up a load suddenly with the motor running — a load such as a car puller or scraper hoist. The booklet contains many cutaway views, sectional drawings, dimensional tabulations, and application illustrations. (7419). American Blower Corporation.

(45) Tube Mills

Off the press is a bulletin describing tube mills for transforming strip steel into mechanical tubing with outside diameters up to 4 in. and standard weight pipe ½ in. through 2 in. The bulletin describes operation of the equipment, illustrates a medium wall tube mill and gives brief specifications. American Electric Fusion Corporation.

(46) New Screen Booklet

A new 4-page booklet, describing the "Style M Vibrex" screen has just been issued. Briefed for quick reading is an explanation of the 2-bearing circle-throw principle employed in this screen, which has adjustable stroke and easy angle-adjustment. The booklet also tells how this screen, whether floor-mounted or suspended, is always in perfect balance. Applications and the full range of sizes in single or double deck styles are included. (122-A). Robins Conveyors division, Hewitt-Robins, Inc.

(47) Valve Catalog

Including more than 70 specially made half-tone photographs, and tables keyed to drawings showing dimensions of valves, a new catalog on the butterfly or disc type valves they produce has just been issued. The volume contains 52 pages and has a particularly easy-to-use index. It shows 11 basic types of R-S butterfly valves, including detailed elevations which reveal manual controls, extended shafts for automatic controls and finned boxes for high temperature service. The tables are keyed to the valve drawings to show dimensions in all sizes from 2 to 48 in. R-S Products Company.

(48) Weld Repair

Simplified welding technique for maintenance and repair of a wide variety of metals, forms, castings, shapes, and heavy machinery components are set forth in a new 4-page bulletin recently issued. Specialized methods, which involve welds made below base metal heat of fusion through surface alloying, are described in considerable detail for major industrial alloys from which equipment is fabricated today. Photographs and diagrams illustrate typical step-by-step operation, when welding spring bases, axles, journals, motor blocks, impellers, malleable and cast iron parts. Brief case histories reflect maintenance problems of heavy, rather than light industry, with samples selected mainly from transport and allied fields. Eutectic Welding Alloys Corporation.

(49) Wear Relief

A new booklet entitled "Relief from Bearing Wear Grief" reveals a new answer to some old problems of power transmission loss and prematurely worn bearings. This booklet reveals how many plants are preventing the destructive waste of downtime caused by bearing failure, shaft failure and damaged equipment through the improper coupling of rotating shafts. This booklet describes the functions of flexible couplings. A thorough explanation and analysis is given to the principles by which couplings operate and their importance in relationship to the equipment it connects.

It presents practical helps to design engineers, plant engineers, master mechanics and maintenance men on how the use of proper flexible couplings prevents downtime caused by bearing failure, shaft failure and damaged equipment. American Flexible Coupling Company.

(50) Flexible Couplings

A new catalog on roller chain flexible couplings has just been released. The new book presents a comprehensive story of Baldwin-Rex couplings, their design, application, selection and prices. To clarify intricate design and application features, cutaway, "explosion" photos and simple drawings are used. Diagrams of the five types of shaft misalignment are shown, and a group of charts make the selection and ordering of couplings an easy task. Baldwin Duckworth division of Chain Belt Company.

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A-B-K Laminated Plastic Bearings

Cut Costs 4 Ways

A-B-K roller neck bearing with separate collar.

A-B-K patented reinforced edge slipper bearing, made to specified blueprint sizes.

Phantom view of A-B-K reinforced edge slipper bearing.

1. Outwear Metallic Bearings
2. Reduce Power Consumption
3. Eliminate Lubricating Oil
4. Require Fewer Adjustments

Steel mill records clearly prove that when metallic bearings are replaced with A-B-K Laminated Plastic Bearings, production goes *up* and costs come *down*. Specifically, A-B-K bearings cut costs four ways:

Outwear metallic bearings—A-B-K laminated bearing material is extremely tough and slow-wearing. It is impervious to mild acids and alkalies, will not distort under shock and withstands temperatures up to 200° F. without failure. In actual service, A-B-K bearings customarily outwear metal several times.

Reduce power consumption—A-B-K Laminated Plastic Bearings have an exceptionally low coefficient of friction which produces remarkable savings in power. The A-B-K surface is self-renewing—actually polishes, but never scores, the shaft.

Eliminate lubricating oil—A-B-K bearings are successfully lubricated with *water*. Cost of oil or grease is eliminated entirely.

Require fewer adjustments—Because A-B-K bearings hold gauge longer, oversize requirements and need for roll adjustments are sharply reduced. This means fewer shutdowns—a higher percentage of productive time from each A-B-K equipped unit.

It will pay you to investigate fully the cost-cutting advantages of A-B-K Laminated Plastic Bearings for your mill. The complete engineering and research facilities of American Brakeblok are at your disposal. Write to arrange a consultation.

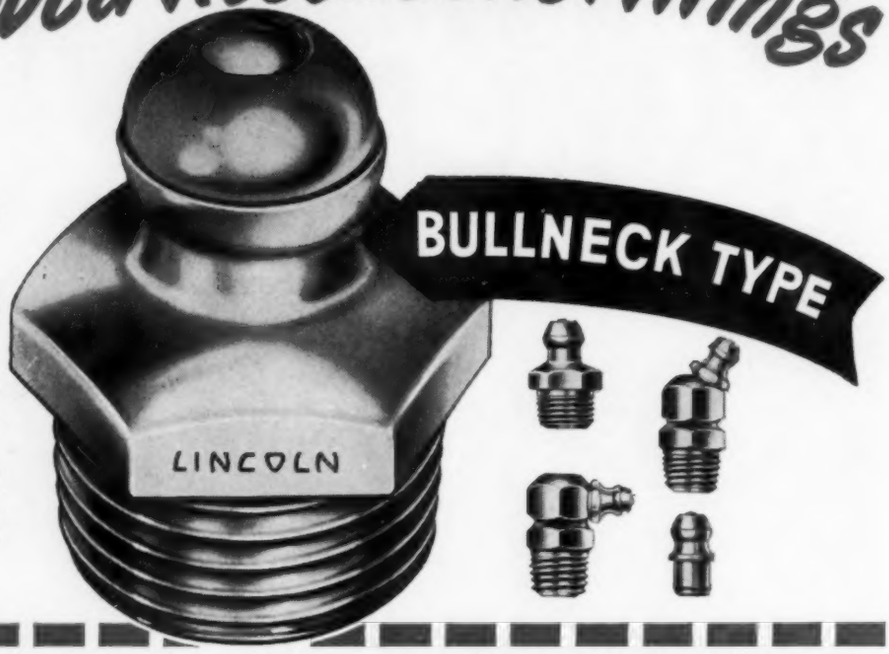
AMERICAN Brake Shoe COMPANY

AMERICAN BRAKEBLOK DIVISION
DETROIT 9, MICHIGAN

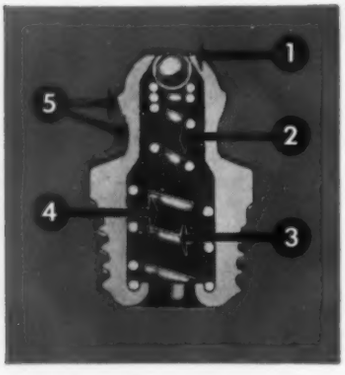
A-B-K
Laminated Plastic Bearings

New Improved KLEENSEAL Fittings

- KEEP DIRT OUT OF BEARINGS...
- REQUIRE LESS PRESSURE BY 20%
- PROVIDE MORE LUBRICANT VOLUME BY 30%
- SECURELY CONTACTED BY ALL COMMERCIAL HYDRAULIC COUPLERS



These Grease Fittings (Bullneck Type), were originally developed by the Lincoln Engineering Company for the United States Army Ordnance Department. They incorporate the most desirable characteristics of former types of high-pressure fittings and permit standardization on one, all-purpose fitting (Bullneck Type). They represent the first major improvement in grease fitting design that does not obsolete couplers and grease guns in general use today—they can be securely contacted by all commercial hydraulic couplers.



Check THESE FEATURES

1. . . . **Flush Ball Check**—Head can be wiped clean without forcing dirt into fitting and into bearing.
2. . . . **Large Grease Passage**—The larger internal diameter permits greater flow of lubricant.
3. . . . **Special Spring Design**—Spring cannot be compressed to restrict flow of the heaviest lubricants.
4. . . . **Greater Flow—Less Resistance**—The larger internal area requires less pressure to clear the fitting.
5. . . . **Sturdier Construction**—Enlarged neck size and projecting locking pad protect against damage and wear.

Trade names LINCOLN, KLEENSEAL, BULLNECK registered U. S. Pat. Office.

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Leaders in Lubricating Equipment for a Quarter Century

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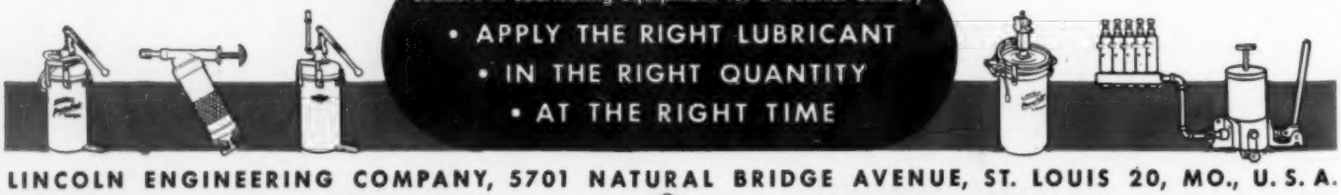
- IN THE RIGHT QUANTITY
- AT THE RIGHT TIME



LINCOLN ENGINEERING COMPANY, 5701 NATURAL BRIDGE AVENUE, ST. LOUIS 20, MO., U. S. A.

NEW YORK—Lincoln Lubricating Systems, Inc.—Trafalgar 7-7900
CHICAGO—Lincoln Engineering Co., of Ill.—Calumet 6022
DETROIT—Lincoln Engineering Co.—Madison 3484
PITTSBURGH—Lincoln Engineering Co.—Montrose 1444
LOS ANGELES—Lincoln Engineering Co., of Calif.—Richmond 0151
CLEVELAND—Lincoln Lubricating Systems, Inc.—Express 4334
OAKLAND—Lincoln Engineering Co., of Calif.—Higate 6130
EAST ORANGE—Lincoln Lubricating Systems, Inc.—Orange 3-3188

Distributors in all Principal Cities.

B48-7

DATE LINE DIARY...

February 2

▲ The operating rate of steel companies having 94 per cent of the steel capacity will be 94.0 per cent for the week beginning February 2, 1948, or equivalent to 1,694,300 tons of steel ingots and castings' compared to 1,716,000 tons one week ago.

February 3

▲ According to Business Comment, a bulletin of the Northern Trust Company, Chicago, the United States is no longer self-sufficient in copper in periods of high industrial activity. Refined copper shipments to domestic consumers last year totaled 1,384,000 tons. Available domestic supplies in 1947 from domestic ores were 860,000 tons and imports for the year totaled 400,000 tons.

▲ Business Comment also states that the government has within its grasp a tremendous anti-inflationary force in the form of an estimated cash surplus of 6 to 8 billions for the current quarter.

February 4

▲ Stock prices suffered the sharpest drop this date since last May, and the market average is at the lowest point since June 10. Commodity prices also dropped and most items plunged the limit permitted in a single session.

February 5

▲ A barrage of letters and telegrams is being fired at the War Assets Administration in a dispute over the sale of a $28,000,000 surplus steel plant in Cleveland. This plant is being sought by the Republic Steel Corporation and by the Tucker Corporation, a new Chicago automobile firm.

February 6

▲ Great Britain has taken out all but $100,000,000 of the $3,750,000,000 loan granted it by the United States in July of 1946.

February 7

▲ Eugene Grace, chairman of the board, Bethlehem Steel Company, announced that the company has authorized $105,000,000 for further expansion of facilities. All but $5,000,000 will be spent in 1948. Fifty per cent of the work consists of improvement and expansion of raw material facilities, particularly coal preparation plants, coke ovens and Venezuelan iron ore properties. The other 50 per cent will be spent on steel finishing facilities. Billings of the company for the first time in its peacetime history amounted to over $1,000,000.

February 9

▲ The operating rate of steel companies having 94 per cent of the steel capacity will be 92.7 per cent of capacity for the week beginning February 9, 1948. This is equivalent to 1,670,900 tons of steel ingots and castings, compared with 1,694,300 tons one week ago.

February 10

▲ Both stocks and commodities skidded sharply in one of the fastest drops for about ten months.

▲ The Lukens Steel Company and its divisions report a consolidated net profit of $487,682.68 after taxes or $1.50 a share for the first quarter of their 1948 fiscal year.

February 12

▲ Steel production in January set a new peacetime record for that month the American Iron and Steel Institute announced today. January's output of ingots and steel for castings was 7,463,112 tons for an average steel operating rate of 93.5 per cent capacity.

▲ In the Pittsburgh area, the increase in railroad freight rates has apparently jumped the economic radius for delivery by truck to about 300 to 350 miles.

▲ The Commerce Department estimated that January construction is $1.1 billion, which is up 32 per cent over January, 1947.

February 13

▲ The American Iron and Steel Institute announced today that the improvement program of steel companies involves expenditures totaling about $1,700,000,000. In 1948 alone, companies in the industry plan to spend a total of $565,000,000 for new equipment and expansion. The companies have already allocated about $265,000,000 for the period after 1948.

▲ United States Department of Labor announced today that continued high employment could be expected in the steel industry. If present levels of employment are maintained, about 12,000 unskilled workers will be needed monthly to replace workers who leave the industry. In December, 128 plants reported that they employed 486,200 workers which is nearly 90 per cent of those in the entire industry. Their number has decreased only 1800 since the previous October. The separation rate in November was only 2.2.

February 14

▲ A new section of the big pipe line of the Tennessee Gas Transmission Company is to be tied in this week and it will bring the output of the system to about 400,000,000 cu ft daily. This will be 100,000,000 cu ft over the 1947 daily average.

February 15

▲ The American Iron and Steel Institute announced today that the amount of iron and steel in use amounted to 14,500 lb for every person in the United States. This is more iron and steel than has been used by the people of the United States at any previous time in their history. The amount in use has increased over three times as fast as the nation's population since 1900, when the per capita figure was 3300 lb.

▲ In spite of tight import controls and a shortage in dollars, exports from the United States reached a new high of $14.5 billion in 1947. Imports totaled $5.7 billion. Steel exports for the year were about 6½ million net tons.

February 16

▲ The government of India has announced plans for two new major steel plants, each of which would have an annual capacity of 500,000 tons. The plants would

be capable of sufficient expansion to double the output. Total capital required would be $148,000,000.

▲ Over 200,000 tons of scrap were placed in the past week at a price $40.58. Inasmuch as this is the steelmaker's formula, this would indicate that the scrap sellers are apparently not figuring on the scrap market going up.

▲ The United Steelworkers of America, CIO, stated that it will not strike as a means to force the steel industry to grant a wage increase this year.

▲ The operating rate of steel companies having 94 per cent of the steel capacity will be 92.5 per cent for the week beginning February 16, which is equivalent to 1,667,300 tons of steel ingots and castings, compared with 1,646,700 tons one week ago.

February 17

▲ In 1947 the steel industry paid out to its employees $1,986,661,000 in wages and salaries. This is an increase of 28 per cent over 1946. Wage earners in the industry made an average of $1.513 per hour, compared with $1.347 in 1946 and $0.818 in 1937. The average work week in 1947 was 38.6 hours. Total industrial employment amounted to 616,300 wage and salaried workers.

February 18

▲ During the 12 years, 1935 to 1946, tax collectors received more money from the steel industry than it earned as its net profit, the American Iron and Steel Institute announced. In this period, tax payments totaled over $3,737,000,000, whereas the industry profits were $2,243,000,000.

February 19

▲ Since February, 1946, pipe prices have been boosted four times. The total price advance in common sizes of merchant black pipe has amounted to $30 a ton. Last week's advance on merchant black pipe was about $7 a ton.

▲ Carnegie-Illinois Steel Corporation put the price of rerolling and forging billets, blooms and slabs on a net ton price basis. Forging grades are now $54 a ton and rerolling items are $45 a ton. These increases are slightly less than $5 a ton.

▲ Great Britain established a new monthly steel production rate in January, when its output was at an annual rate of 14,000,000 tons.

February 20

▲ The National Steel Corporation declared a dividend of $1.00 per share for the first quarter of 1948.

▲ Benjamin F. Fairless, president of United States Steel Corporation, stated today that there "has been no general increase by Carnegie-Illinois Steel Corporation in the prices of its finished steel products . . . the semi-finished products covered by the adjustment include ingots, blooms, billets, slabs, tube rounds and skelp . . . shipments during 1947 of such semi-finished material by the entire steel industry represent less than 4 per cent of total shipments of steel by the industry during that year."

February 22

▲ The American Iron and Steel Institute announced that the wages and salaries paid by the iron and steel industry accounted for 39.2 per cent of all wages paid to employees of manufacturing industries in 1946. Wages and salaries paid by the iron and steel industries and steel fabricating manufacturers totaled $14.1 billions during 1946, compared with $36.0 billions paid to employees of all manufacturing industries. Basic steel producing and rolling plants plus a few other manufacturers accounted for $4.5 billions of the 1946 total.

February 23

▲ The CIO United Steelworkers Union's executive board will meet in Pittsburgh on March 25 to consider demands against non-basic steel companies. The union has pledged that it will adhere to its no strike contracts regardless of what decisions are reached in the negotiations. They will, however, press wage boost demands on the basis of the increased cost of living and because of the ability of the industry to pay higher wages.

February 24

▲ The operating rate of steel companies having 94 per cent of the steel capacity will be 93.6 per cent of capacity for the week beginning February 23, or 1,687,100 tons of steel ingots and castings, compared with 1,667,300 tons one week ago.

February 25

▲ The American Iron and Steel Institute announced that of all the alloy steels produced since the end of the war, about 1/8 of the total were "N.E." or National Emergency steels. Some of these steels have proved to be highly useful for peacetime purposes and remain in demand, although the need for conservation of alloys has been greatly lessened.

February 26

▲ The Texas Eastern Transmission Corporation spent $4,900,000 during its first eight months of operation to increase its daily delivery rate of natural gas through its Big Inch and Little Big Inch pipe lines from 140,000,000 cu ft to 235,000,000 daily. The company plans to spend an additional $20,100,000 for construction to reach a daily delivery rate of 433,000,000 cu ft a day to ten utility companies serving communities in Ohio, Pennsylvania, West Virginia and Indiana. Completion of this schedule is set for next fall.

February 27

▲ Mr. C. M. White, president of Republic Steel Corporation, in a letter to one of the trade magazines made the following significant statement: "Not only have I not advocated lower steel prices, but quite to the contrary, I have publicly declared and still do firmly believe that steel prices are not high enough to assure the industry of firm financial experience in the months and years to come . . . . unless some material reduction in our present costs comes about."

February 28

▲ It is beginning to be apparent that the bankers are starting to put the brakes on credit. This has been shown in several factors and they are: The mildly restrictive measures that the Federal Reserve Board has applied to the money market; the repeated warnings from federal and state bank supervisory authorities advising caution in their lending policies; the campaign for voluntary restraint being conducted by the American Bankers Association; and a general uneasiness over the rapid increase in loans to business and agriculture in the past two years.

February 29

▲ It is estimated that demands for steel in Great Britain in 1948 will range from 15,250,000 to 15,500,000 tons of steel ingots and castings. Latest estimates place maximum production at 14,000,000 tons at home, and about 500,000 tons will be available from imports. Thus, there will be a shortage of from 1/4 to 1/2 million tons during the year.

PUTTING ON THE PRESSURE

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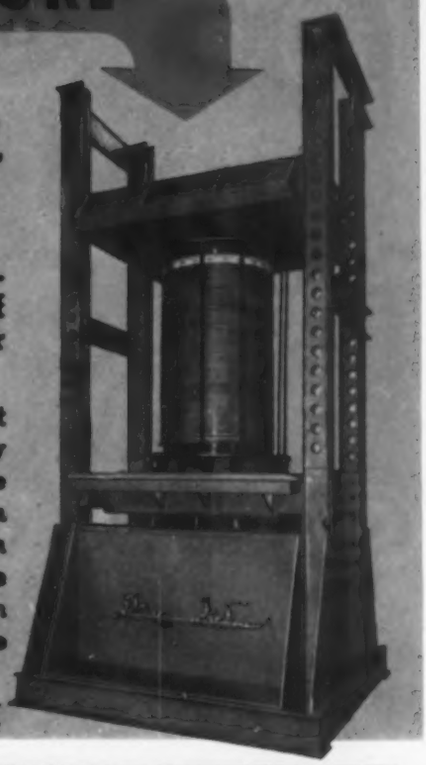
It's sure. It's positive. No guess work. No wishful thinking. Putting on the pressure is an added measure of safety engineered into every Pennsylvania Transformer with helical or pancake coils.

THIS IS WHAT WE DO — We calculate the total short circuit force that would be produced by a short circuit at the secondary terminals with the rated voltage maintained on the primary. We compress the coils with this pre-determined force and treat them in such a manner that they are self-supporting, and will maintain their shapes when mounted on the core. Strong supports are provided at the top and bottom of the coils to keep the coils in their precompressed shapes. No movement can take place in the transformer coils, even under the most severe short circuit.



Hydraulic Press capable of applying pressures up to 600,000 lbs.

8333 Kva
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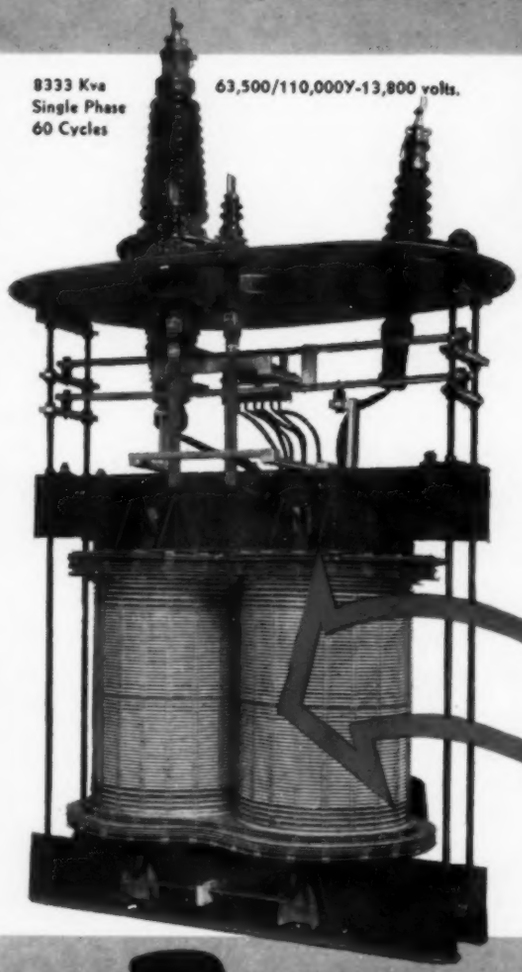
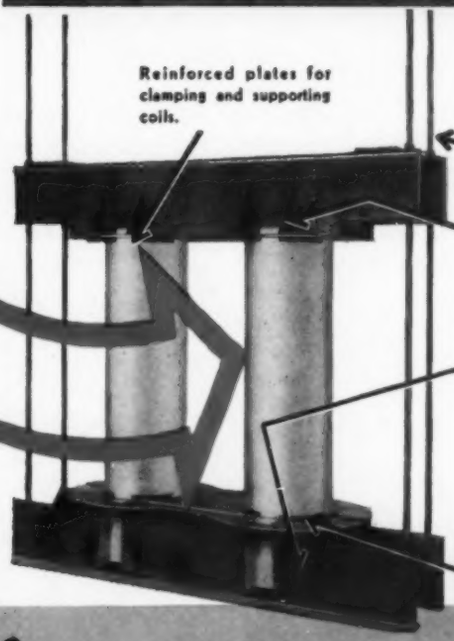
60 Cycles

63,500/110,000Y-13,800 volts.



THE ABILITY OF THE TRANSFORMER COILS TO MAINTAIN THEIR SHAPES UNDER THE PRESCRIBED PRESSURE IS YOUR GUARANTEE THAT THE TRANSFORMER WILL WITHSTAND SHORT CIRCUITS.



Reinforced plates for clamping and supporting coils.

Tie rods for connecting top and bottom core frames and for clamping coils.

Clamping plates hold coils to their precompressed size. Note the ruggedly constructed side-frames, the extra strong bolts, nuts and rods.

Drum cut away to permit cooling oil to flow past core steel.

Pennsylvania

TRANSFORMER CO., PITTSBURGH, PA.

Pennsylvania TRANSFORMERS

An example of how carbon-brush standardization paid a large company

A LARGE industrial company had been ordering 12 types of carbon brushes for one type of motor, in small lots of 25 to 450. By utilizing the brush-standardization methods recommended by National Carbon Company, Inc., it was found that *one* type of brush could be used on all the motors. This company then ordered their annual supply of 6000 carbon brushes for this type of motor in 3000-item lots and saved $870 – simply by buying in more economical quantities.

If you use carbon brushes – just a few or many thousands – you can save time and money by writing to National Carbon Company for detailed recommendations on how to simplify brush stocks. Or, if you prefer, call in a National Carbon Company representative for on-the-job consultation.

HOW BRUSH
STANDARDIZATION PAYS
1. Permits buying in economical quantities.
2. Fewer small orders—with savings in bookkeeping, billing, and accounting.
3. Less money and space tied up in brush stocks.
4. Less time needed to handle stock.

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Personnel News . . . .

Sigurd Landen was appointed Chicago district chief engineer of Carnegie-Illinois Steel Corporation. A native of Grangesberg, Sweden, and a graduate of Chalmers Institute of Technology at Gothenburg, Mr. Landen has been with Carnegie-Illinois since October 27, 1924. He started as a draftsman. He served as assistant chief engineer for three years before becoming chief engineer eight years ago.

F. H. Johnson has been appointed an assistant chief engineer of Carnegie-Illinois Steel Corporation. Mr. Johnson, who attended Armour Institute of Technology and Northwestern University, came to Carnegie-Illinois in 1940 as an engineer at South works in Chicago. Previously he had been employed 25 years in the steel industry with Minnesota Steel Company and Interlake Iron Corporation. He was made defense engineer in Pittsburgh in 1941, having charge of engineering for DPC construction here. He was chief engineer for the Chicago district of the company at the time of his present appointment.

Ernest E. Brayshaw has been named works manager of the Southwest Steel Rolling Mills, Los Angeles, California. Formerly assistant division superintendent of the Carnegie-Illinois Steel Corporation, Clairton, Pennsylvania. Mr. Brayshaw entered the steel business as a roll designer for the Bethlehem Steel Company, Bethlehem, Pennsylvania. He is a graduate of Carnegie Institute of Technology, with a degree in mechanical engineering.

C. Richard Newpher, production manager of the Ivanhoe division of Reliance Electric and Engineering Company for the past two years, has been made division manager.

In his enlarged responsibilities, Mr. Newpher will also have charge of the plant at 1170 Ivanhoe Road, purchased by Reliance from the Detroit Steel Corporation. He has been with Reliance since his graduation in mechanical engineering from Case Institute of Technology in 1937.

Bradford C. Colcord has been elected president of the Woodward Iron Company, Woodward, Alabama.

Mr. Colcord has resigned as general superintendent of National Tube at Lorain, Ohio. He began his business career as a blower at a Jones and Laughlin blast furnace in Pittsburgh, and subsequently became superintendent of blast furnaces for Crucible Steel Company at Midland, Pennsylvania.

After a period of blast furnace supervision with southern companies, he joined National Tube in 1936 at Ellwood City, later becoming general superintendent at National works in McKeesport and assistant to the vice president in charge of operations.

Edward O. Burgham, assistant general superintendent of Weirton Steel Company since 1944, has been promoted to general superintendent. Mr. Burgham, associated with the company since 1915 with the exception of three years, succeeds **Clyde E. Bayer**, who was promoted to assistant vice president in charge of operations at Great Lakes Steel Corporation, which, like Weirton, is a National Steel subsidiary.

F. A. Wright, assistant general sales manager, Cutler-Hammer, Inc., was elected chairman of the advisory committee, industrial control section of NEMA. Mr. Wright has been active in NEMA for a number of years having served previously as vice chairman and as chairman of the industrial control section.

A. R. Johnson, manager of merchandising sales, Cutler-Hammer, Inc., was elected chairman of the knife and enclosed switch section, NEMA. He previously served as vice chairman of this section and as chairman of the advisory committee of the knife and enclosed switch section.

R. A. Millermaster, assistant manager of development, Cutler-Hammer, Inc., has been elected chairman of the general engineering committee of the knife and enclosed switch section, NEMA. He also has been appointed chairman of the general engineering committee, small air circuit breaker section.

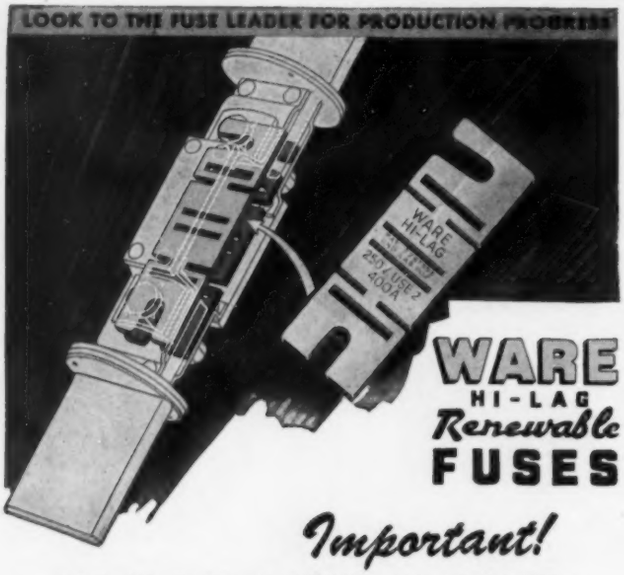
W. H. Dupka, vice president and controller of the

SIGURD LANDEN

F. H. JOHNSON

ERNEST E. BRAYSHAW

C. RICHARD NEWPHER



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Renewable
FUSES

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HI-LAG LINK DESIGN

One piece thickness of renewal link, produces strong lag characteristics.

The WARE HI-LAG Renewable Links are designed to provide longer time lag for handling starting, as well as other temporary harmless overloads. Always assuring 100% Protection.

Note exclusive design of WARE HI-LAG Links: the square ends which increase contact areas and maintain low resistance without overheating; the wide metal areas in body, which absorb excessive heat from motor starting current and short heavy surges; the narrow cross members, which allow for expansion without sharp bending; the fusing points, which open with a minimum of arcing on short circuits.

No fuse is more dependable than its link. The WARE HI-LAG Renewable Link of one piece and uniform thickness, insures dependable absorption of heat for time lag. Other exclusive features include the Spring Tension Locking of Links into Circuit—Double Bridge Knife-Blade Assembly—Gas Vents and Simplified Construction, only 3 Parts.

HI-LAG FERRULE FUSE CONSTRUCTION

Our ferrule type fuse has a heavy brass bar, which locks into open end ferrule, bridging fuse case. This bridge locks link to prevent twisting and cap tightens on new center contact. No sagging washers or twisted links to cause overheating.

Investigate today! Start economizing with the World's Best and Coolest Operating Fuse.

Write for Fuse Booklet No. 4460 giving all features, sizes and details.

WARE Brothers 4450 W. LAKE ST. - CHICAGO 24, ILL.

Jones and Laughlin Steel Corporation, has been elected a director.

Charles T. Slonaker was elected chairman of the board and president of Hyde Park Foundry and Machine Company, Hyde Park, Pennsylvania. Mr.

C. T. SLONAKER

Slonaker has been at this firm in an engineering and sales capacity for many years. He will also act as general manager.

Edward M. McCausland has been elected vice president and assistant general manager of Hyde Park

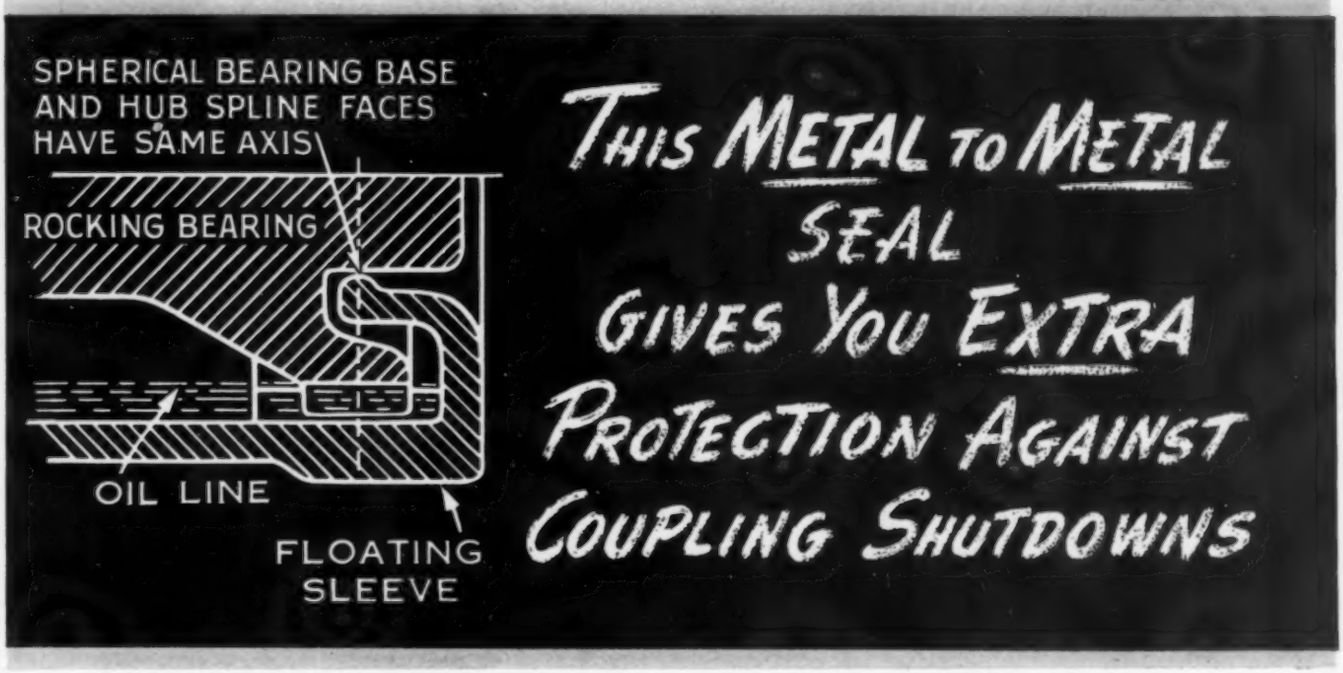
E. M. McCAUSLAND

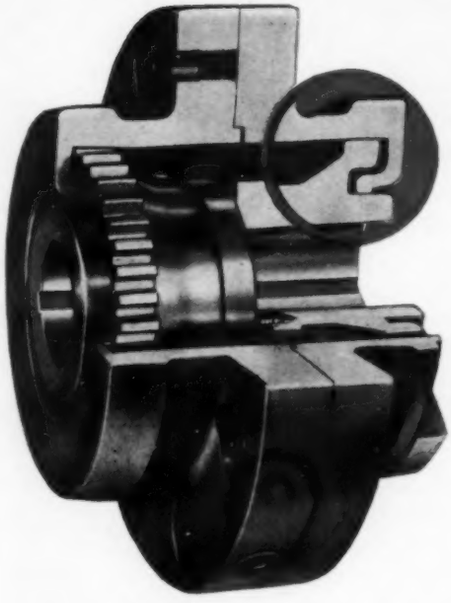
Foundry and Machine Company, Hyde Park, Pennsylvania. Mr. McCausland has been active in the rollmaking end of this firm which was established in 1895.

G. Edward Clifton was elected secretary and treasurer of Hyde Park Foundry and Machine Company, Hyde Park, Pennsylvania. Mr. Clifton for many years has been office manager of the company and is well versed in all the activities of the industry.

George I. Bottcher, construction engineer since May, 1946, has been appointed assistant chief engineer of the Allegheny Ludlum Steel Corporation, with headquarters at Brackenridge, Pennsylvania. Before joining Allegheny Ludlum in 1940, Mr. Bottcher had been with the Bureau of Yards and Docks, Navy Department, and with the construction division of the War Depart-

What's the BIG IDEA in Fast's Couplings?


SPHERICAL BEARING BASE AND HUB SPLINE FACES HAVE SAME AXIS
ROCKING BEARING
OIL LINE
FLOATING SLEEVE
THIS METAL TO METAL SEAL GIVES YOU EXTRA PROTECTION AGAINST COUPLING SHUTDOWNS



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We have a complete line of couplings for immediate delivery. When you buy any one of them, you buy years of top engineering experience, Koppers' high standard of workmanship and unexcelled coupling service that assures a ready source of spare parts, no matter how old your couplings may be. Result: longer machine life, lower upkeep costs, minimum shutdown losses. For full information on Fast's, the *original* gear-type coupling, fill out the coupon below and mail it to: Koppers Co., Inc., Fast's Coupling Dept., 213 Scott St., Baltimore 3, Maryland.

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SEND FOR FREE CATALOG giving detailed descriptions, engineering drawings, dimension and capacity tables, and typical installation photographs for the many types of Fast's Couplings. Fill out this coupon and mail it to: Koppers Co., Inc., Fast's Coupling Dept., 213 Scott St., Baltimore 3, Md.

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Company.....

Street..... City..... State.....

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ment. He is a graduate of Cornell University, and also attended Montana State University.

Robert L. Stephenson was appointed chief metallurgist of Carnegie-Illinois Steel Corporation's Duquesne works. Mr. Stephenson was graduated from Princeton University in 1935 with a Bachelor of Arts degree in chemistry. He was first employed in July, 1935 at the Duquesne works as an observer. In October, 1937 he was made laboratory foreman, which position he held until January 1942 when he was made assistant to chief metallurgist. In August, 1943 he was made assistant chief metallurgist holding the latter position until his present appointment.

Laverne G. Ekholm was promoted to assistant chief metallurgist, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania. Mr. Ekholm is a 1937 graduate of the University of Illinois with a bachelor of science degree in ceramic engineering. He started his

LAVERNE G. EKHOLM

steel mill career with the Duquesne works in June, 1937 as an observer. In November, 1940 he was made metallurgical engineer, and in July, 1943 he was appointed assistant to chief metallurgist (development). He held the latter position until his present appointment.

R. J. Ritchey, now manager of market development of Carnegie-Illinois Steel Corporation, United States Steel subsidiary, has been appointed director of the new division of the United States Steel Corporation. Mr. Ritchey, who attended the University of Pittsburgh and Temple University, began his service with Carnegie-Illinois in 1937 in the sales promotion division of the sales department. He was made assistant manager of the company's market development division in 1942, and manager in 1945.

Robert C. Myers was appointed manager of the market development division of Carnegie-Illinois Steel Corporation. A graduate of the University of Pittsburgh, Mr. Myers joined Carnegie-Illinois in 1939 as a development engineer in sales promotion. He previously was an assistant merchandise manager with Kaufmann Department Stores, Inc.

Mr. Myers served with the Navy during the war and is a lieutenant commander in the U. S. Naval Reserve.

J. Donald Rollins, who for the last five years has served as assistant chief engineer of Gary works,

FOUND . . . . . at last!

a practical LIGHT for STEEL MILLS

HERE'S THE ANSWER

Here's a lighting fixture with permanent lighting efficiency. A double wall (see "A" above), hermetically sealed, one piece removable glass reflector—the glass outer walls (see "B") protect the special high reflecting silver, spun coated on the inside (see "C") of the double glass walls.

Glass protects silver from darkening or discoloring, the dead air space between two walls of reflector acts as an insulator against heat of lamp—preventing cracking, checking or peeling of silver. Can easily be cleaned without removing from fixture with any solution and will not harm silver.

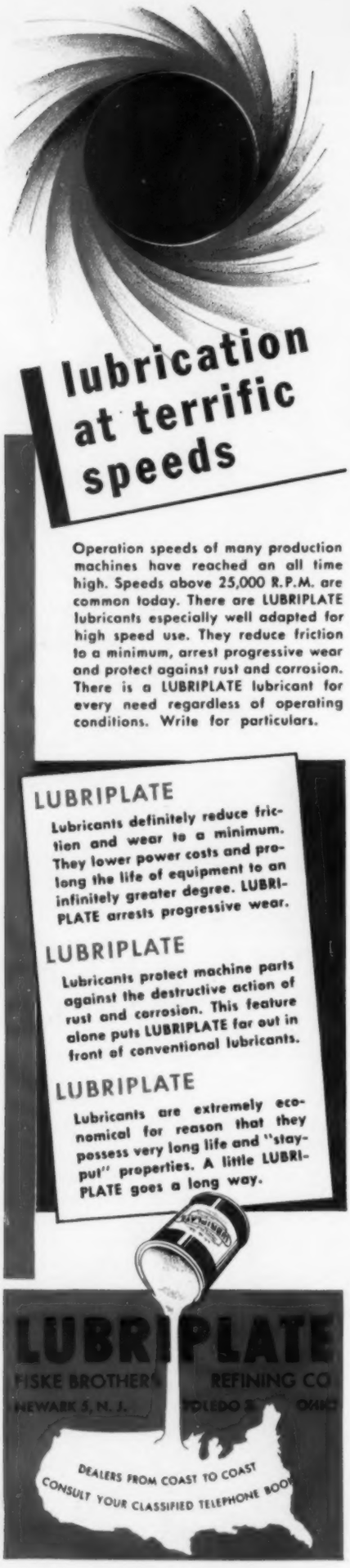
Ask to see "The Midwest Champion," the light that pays for itself in no time. Increase production, cut down rejects and reduce accidents. NOTHING COSTS LESS THAN THE BEST LIGHT.

Write Today

Write today for catalog No. 9. Take the first step towards better production NOW.

The Midwest Lighting Products Co.

1357 BEACH PARKWAY
CLEVELAND 7. OHIO


lubrication at terrific speeds
Operation speeds of many production machines have reached an all time high. Speeds above 25,000 R.P.M. are common today. There are LUBRIPLATE lubricants especially well adapted for high speed use. They reduce friction to a minimum, arrest progressive wear and protect against rust and corrosion. There is a LUBRIPLATE lubricant for every need regardless of operating conditions. Write for particulars.
LUBRIPLATE
Lubricants definitely reduce friction and wear to a minimum. They lower power costs and prolong the life of equipment to an infinitely greater degree. LUBRIPLATE arrests progressive wear.
LUBRIPLATE
Lubricants protect machine parts against the destructive action of rust and corrosion. This feature alone puts LUBRIPLATE far out in front of conventional lubricants.
LUBRIPLATE
Lubricants are extremely economical for reason that they possess very long life and "stay-put" properties. A little LUBRIPLATE goes a long way.
LUBRIPLATE
FISKE BROTHERS REFINING CO
NEWARK 5, N. J.
DEALERS FROM COAST TO COAST
CONSULT YOUR CLASSIFIED TELEPHONE BOOK

Carnegie-Illinois Steel Corporation, was promoted to the post of chief engineer of this U. S. Steel subsidiary plant. He succeeds Sigurd Landen who has been promoted to position of Chicago district chief engineer of Carnegie-Illinois. Mr. Rollins has been associated with the corporation subsidiaries for the last 14 years.

J. DONALD ROLLINS

He began as an estimator in the Pittsburgh engineering department of the subsidiary American Sheet and Tin Plate Company. His Gary association began May 7, 1937, when he transferred as an estimator in the engineering division and progressed steadily until five years ago when he became assistant chief engineer.

Henry A. Anderson has been appointed manager of the coupling division, at John Waldron Corporation, New Brunswick, New Jersey. Mr. Anderson was formerly an executive in the sales and engineering departments of Ingersoll-Rand Company, with whom he had been associated since receiving his degree in electrical engineering, at the University of Minnesota in 1927.

Charles A. Tunner, formerly assistant maintenance superintendent, alloy tool steel division, Bethlehem Steel Company, Bethlehem, Pennsylvania, died recently.

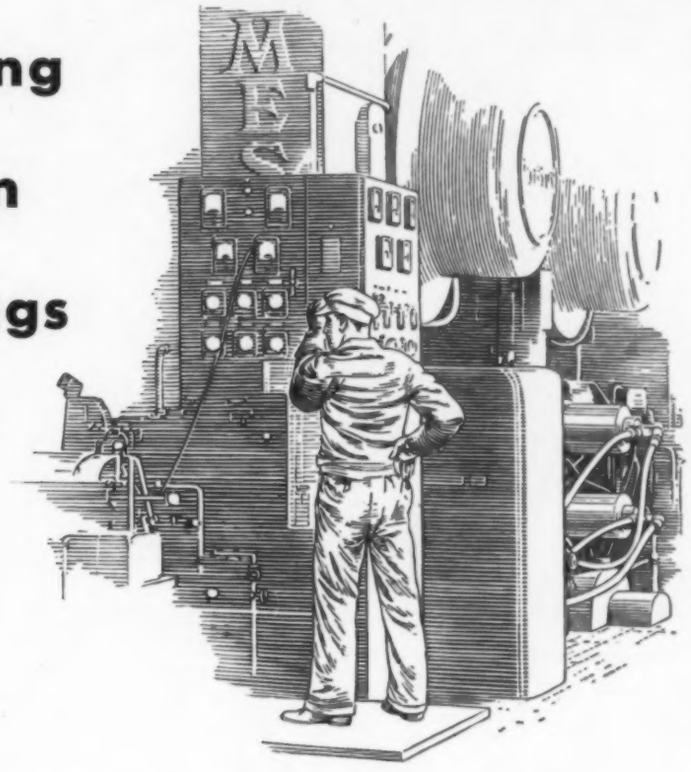
C. E. Duffy has succeeded **A. J. Fisher,** as fuel engineer of the Sparrows Point, Maryland, plant of the Bethlehem Steel Company. Mr. Fisher has been transferred to the home offices in Bethlehem, Pennsylvania as assistant chief of construction.

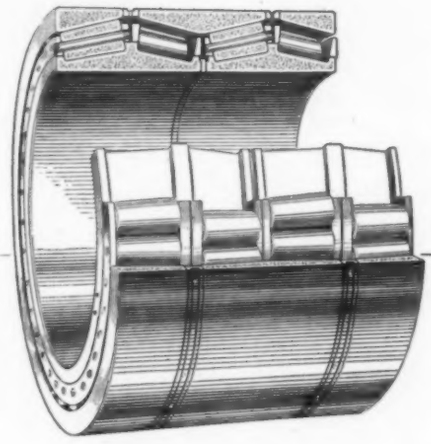
G. W. Paulin, who joined the Allegheny Ludlum Steel Corporation as a chemist in 1920, is new chief metallurgist at the West Leechburg plant, succeeding **F. G. Benford,** recently appointed assistant plant manager at Leechburg. Mr. Paulin attended Carnegie Institute of Technology, and for a time was part-time instructor there in chemistry. As chief metallurgist, he will direct the activities of 14 persons and is charged with the responsibility of seeing that steel produced at West Leechburg meets the requirements of our customers, determining their needs and developing information that will help us be of greater service to the people who buy our steel.

George Nicholas, one-time scrap boy in the Allegheny Ludlum Steel Corporation sheet mill, is the new superintendent of No. 1 pack mills, Brackenridge,

Mesta hot strip mills incorporate the many advantages of Torrington Roll Neck Bearings.

Continuous Rolling With Torrington Roll Neck Bearings





...higher load factor—an advantage possible because of proportioned design and high radial and thrust capacity of Torrington four-row Tapered Roller Bearings.

AS EACH SLAB slams through the stands, you can count on Torrington Bearings to keep the mill rolling out record tonnages. Here are the reasons why: Provision is made for greater strength in roll necks as well as in the bearings... Increased neck diameters are allowed by the minimum cross-section... Closer spacing of rollers means higher radial and thrust capacity to handle heavy shock loads. These features, together with the efficient lubrication system provided in the bearing design, assure maximum service life.

Assure yourself this kind of performance on work rolls, back-up rolls, screw downs, edgers, shears, table rolls and pinion stands by ordering Torrington Bearings for your equipment.

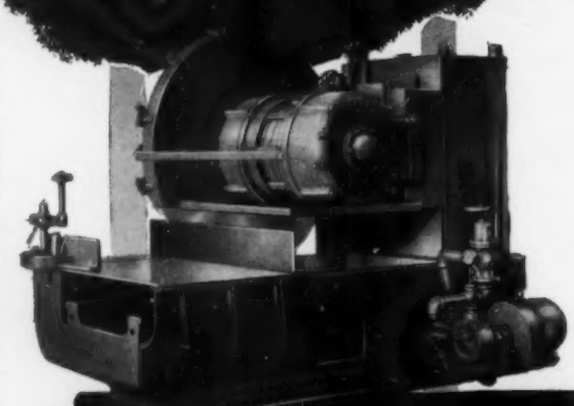
For follow-through service, call on the specialized skills of Torrington's engineers, who have had extensive experience in designing, building and applying anti-friction bearings in the steel industry. Call or write the nearest Torrington office.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District Offices and Distributors in Principal Cities

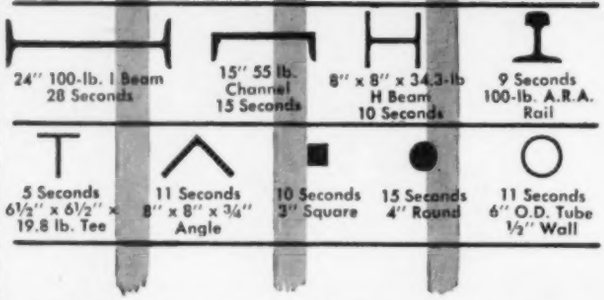
TORRINGTON BEARINGS

SPHERICAL ROLLER
TAPERED ROLLER
STRAIGHT ROLLER
NEEDLE
BALL
NEEDLE ROLLERS

Modern Sawing



with KLING HIGH SPEED FRICTION SAWS



Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut. Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

KLING BROS. *Engineering Works*

Punches; Bar, Angle and Rotary Shears; Combination Shear, Punch and Copers; Plate and Angle Bending Rolls; Heavy Duty Grinders

1324 N. KOSTNER AVENUE, CHICAGO 51, ILLINOIS, U. S. A.

Pennsylvania, succeeding **Art Curry,** retired. In his 44 years with the company, Mr. Nicholas also has worked at shearing, opening, and doubling in the hot mill, as weighmaster and stocker foreman and pack mill foreman.

H. S. Robertson was elected vice president of Harbison-Walker Refractories Company. Associated with Harbison-Walker since his graduation from the University of Illinois in 1916, Mr. Robertson's activities

H. S. ROBERTSON

have been devoted almost exclusively to sales. In 1940 he was appointed general sales manager, and since 1943 has been a director of the company.

M. G. Sternberg was elected president of Continental Foundry and Machine Company. Formerly executive vice president, Mr. Sternberg became associated with

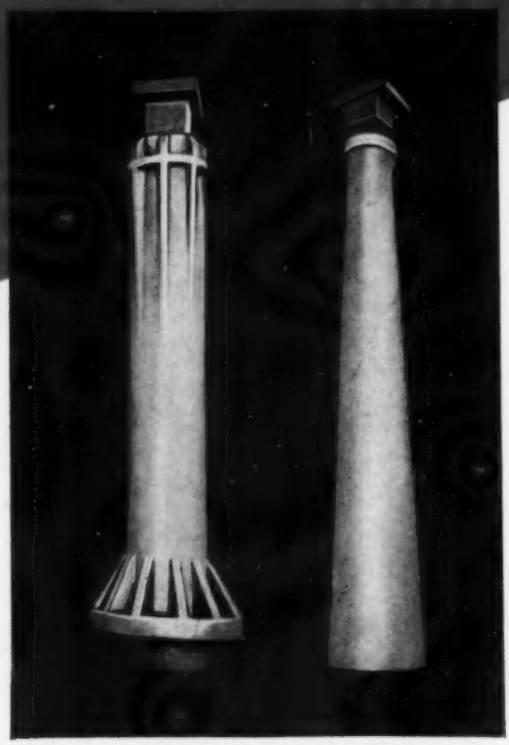
M. G. STERNBERG

Continental in 1918. During World War II he was in charge of production and the development of cast armor of which Continental was then the nation's largest producer.

R. H. Semple, Jr., is now associated with J. K. Mahaffey and Son. Mr. Semple is a 1942 graduate from Yale University. He entered the Army early in 1941 and was mustered out of service in December, 1945. He will be located at the new headquarters for J. K. Mahaffey and Son in Rooms 3117-3118 Jenkins Arcade Building, Pittsburgh, Pennsylvania.

FOR HOTTER FUELS

BIGGER LOADS



UNION ALLOY STEEL PEELS

Except for the charge itself, no piece of unprotected metal is subjected to greater heat for a longer time than the peel. And, hot or cold, it must withstand severe shock and stresses as well. "Union" has developed for this tough service peels of heat and shock resistant alloys in designs that add months to their useful life. ... Glad to quote from your specifications on either rough or fully machined castings.

UNION DOUBLE LIFE HEAD CHARGING BOXES

You'll be quick to see and appreciate the difference! That specially designed, reinforced head means "double life" without cracking or distortion ... All square corners have been replaced by round ones which lend themselves to better casting process ... Union Boxes are cast from UNIVAN—a special nickel-vanadium steel that maintains its superior strength under extreme conditions of heat, cold and shock ... Whether you operate with 20, 25, 36 or even 50 cu. ft. capacity charging boxes, we welcome the opportunity to prove that you can do a faster charging job for a longer time at less cost with Union Double Life Head Boxes ... Your request for further details and prices will receive immediate attention.

"UNIVAN"

UNION STEEL CASTINGS

DIVISION OF BLAW-KNOX CO., PITTSBURGH, PA.

Cinder Pots • Slag Pots • Coupling Boxes • Spindles • Gears • Bells and Hoppers • Ingot Cars • Charging Cars • Annealing Boxes and Bases

A. E. Murton was elected vice president of Continental Foundry and Machine Company. A graduate of the University of Illinois, Mr. Murton has been in the

A. E. MURTON

steel business since 1925, when he joined the roll division of Continental.

William B. Skinkle, registered professional engineer, has completed forty years service with a major steel producer, the last thirty years of which have been devoted to the solution of power and related economic problems. His services are now available for consultation on matters pertaining to fuel and power programs; public utility rate and purchased power problems; industrial economic studies. Mr. Skinkle is located at 912 Ridge Avenue, Coraopolis, Pennsylvania.

F. J. Schaeffer was made assistant director of industrial relations of National Tube Company. A native of Vandergrift, Pennsylvania, Mr. Schaeffer started with U. S. Steel as a helper in the sheet mills of American Sheet and Tin Plate Company. He joined National Tube in 1944 after holding supervisory positions with Jones and Laughlin Steel Corporation, Republic Steel Corporation, and Talon, Inc.

Obituary

Harry W. Reade, 56, apparatus sales manager for the Air Reduction Sales Company, died suddenly at Jersey City, Sunday, February 15, 1948. Mr. Reade was born at Balston Spa, New York, November 26, 1891. He settled in Jersey City thirty-four years ago, at which time he started his business career with the Davis-Bournonville Company, manufacturers of oxyacetylene welding and cutting equipment.

Thomas Moses, formerly president of the H. C. Frick Coke Company and other coal producing subsidiaries of United States Steel and later vice president of United States Steel Corporation of Delaware, died recently at the age of 78 in the St. Elizabeth Hospital, Danville, Illinois.

He retired in 1945 after over 50 years service with U. S. Steel subsidiaries. In 1938 when he became vice president of the Delaware Corporation, his son, **Harry M. Moses,** succeeded him as head of the coal mining subsidiaries. Recently he has served as director of Mines and Minerals for the State of Illinois.

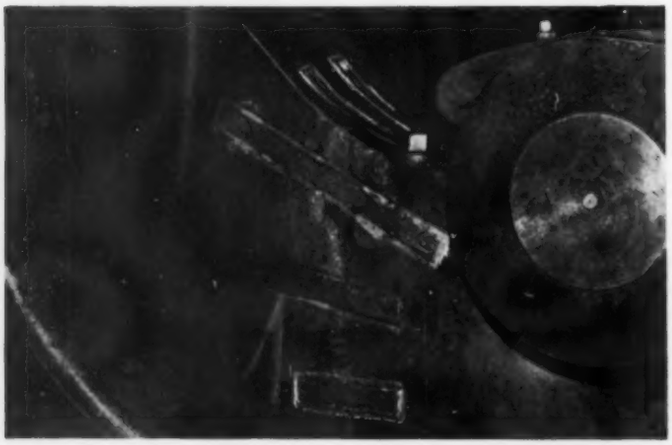
Mr. Moses was of Welsh coal mining ancestry and was born at Audenreid, Pennsylvania, August 18, 1869. He attended public grade school for two short terms and subsequently received private instruction at home. Mr. Moses advanced his education by completion of a correspondence course.

He was employed in the coal mines of Indiana at the age of 11 and at 14 became a coal miner as had been his father and grandfather in Wales. In 1888 Mr. Moses went to the Illinois coal fields and a year later entered the Westville, Illinois, field at operations of the Kelly Coal Company, later acquired by the United States Fuel Company. Mr. Moses filled various positions as miner in the Illinois field until 1905.

Mr. Moses served as secretary of the Illinois State Mining Board from 1905 until 1907, and from 1907 until November, 1910, was Illinois State mine inspector. For the five-year period from 1910 to 1915 Mr. Moses was superintendent of the Westville, Illinois operations of the United States Fuel Company, succeeding in 1915 to the position of general superintendent. In 1927 Mr. Moses was elected president of the H. C. Frick Coke Company, U. S. Coal and Coke Company and other coal producing subsidiaries of United States Steel Corporation. On January 1, 1938, he assumed the title and responsibilities of the office of vice president, raw materials, of United States Steel Corporation of Delaware.

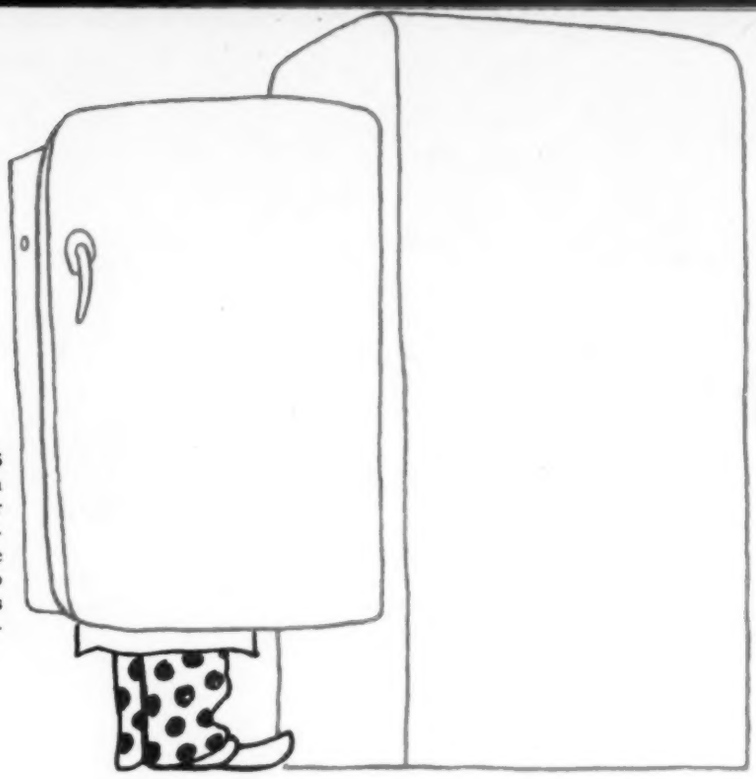
METALOCK
Registered Trademark
A MECHANICAL REPAIR FOR WRECKED MACHINERY
THOUSANDS SAVED BY *On location* REPAIRS WITH METALOCK

STEAM ENGINE FRAME SAVED BY METALOCK AFTER WELD FAILED



NOTE: Masterlocks used to distribute loads beyond area damaged by weld. ***Literature mailed on request***

METALOCK REPAIR SERVICE
General Office: Pennsylvania Division, 530 WILLIAM PENN PLACE
PITTSBURGH 19, PA.
HOME OFFICE: LONG ISLAND CITY 1, NEW YORK



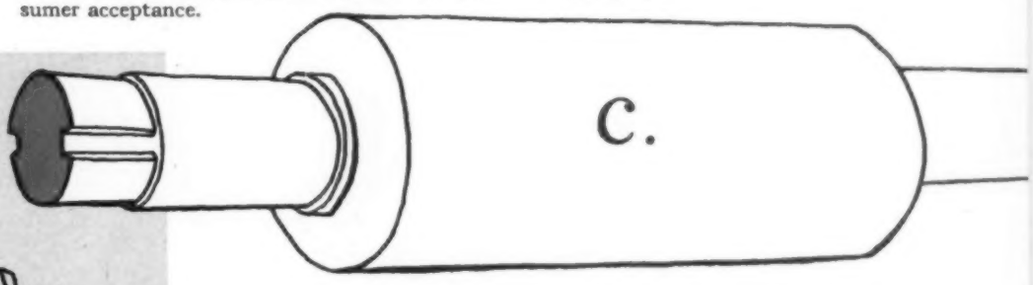
a.

MILLIONS OF REFRIGERATORS and other appliances which Americans will buy this year and every year account for thousands upon thousands of the tons of iron and steel which keep American iron and steel mills rolling along in seemingly endless production.

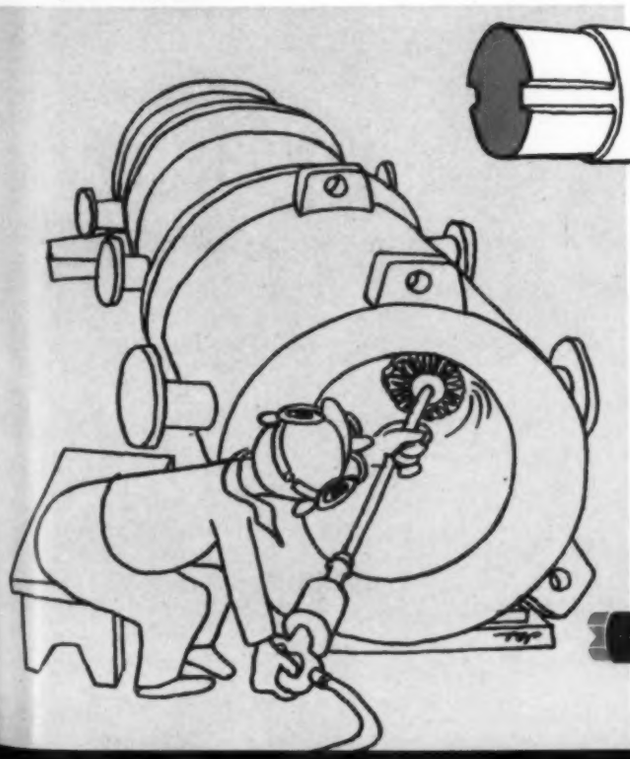
b.

THOUSANDS OF TONS of steel and iron, rolled in virtually unlimited size and finish specifications, require the services of skilled operators—practical mill men who control the rolling conditions and maintain the standards which assure consumer acceptance.

RED WABBLER ROLLS fulfill your exacting demands because your own rolling-mill know-how—the accumulated skill of years of experience—guides Mack-Hemp engineers in the development of rolls which establish production records and set the standards of excellence for uniformity and finish.



c.



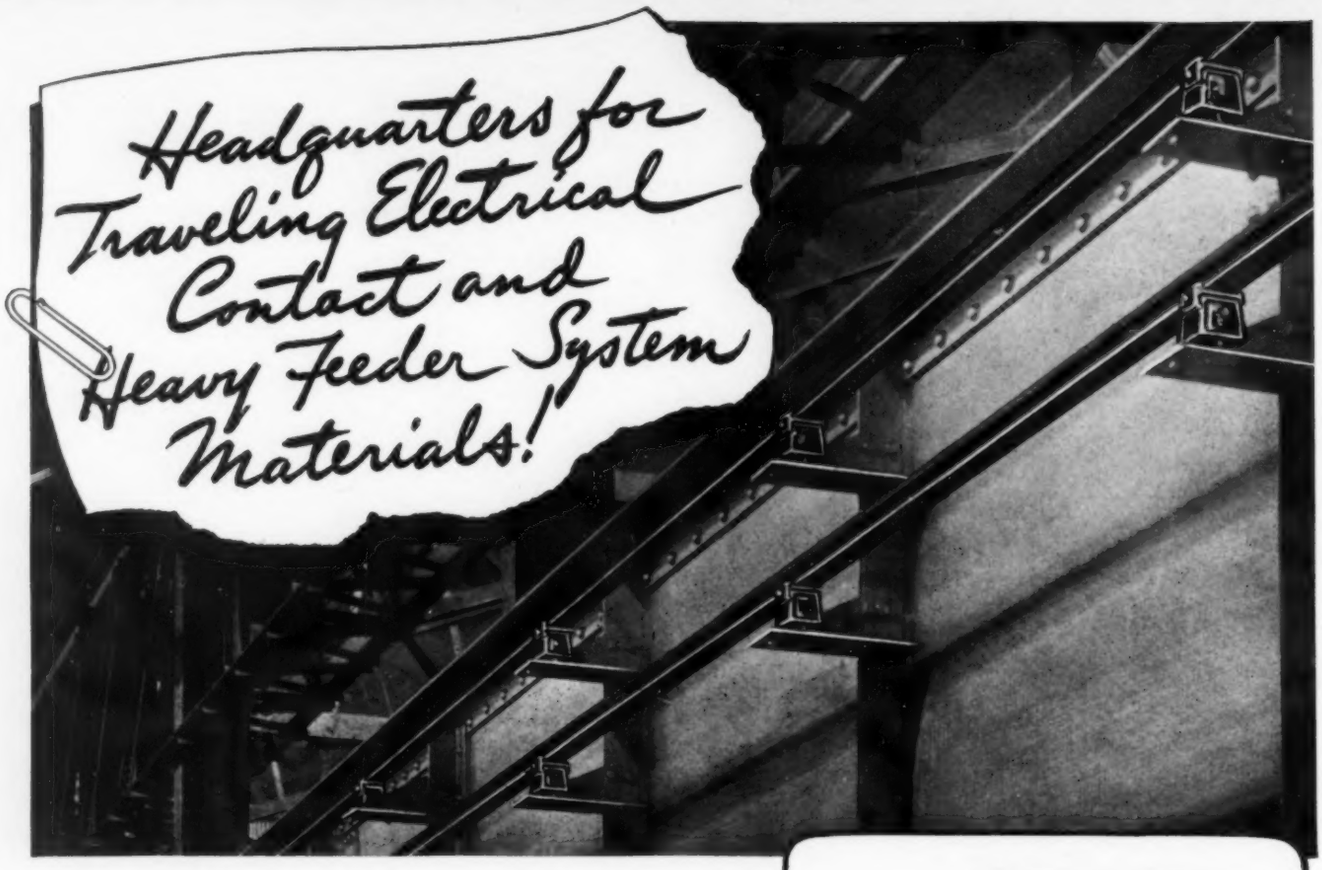
d.

MACK-HEMP CRAFTSMEN and mill-wise M-H engineers continue to combine their skills to supplement your know-how in the design, metallurgy and manufacture of Red Wabbler Rolls—the proper rolls for your production rolling operations.

MACKINTOSH-HEMPHILL CO.

PITTSBURGH AND MIDLAND, PA.

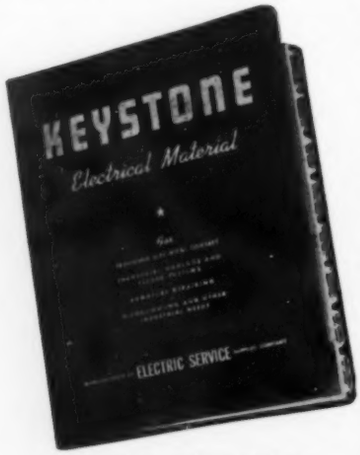
Makers of the rolls with the red wabblers



KEYSTONE Contact Rail Material

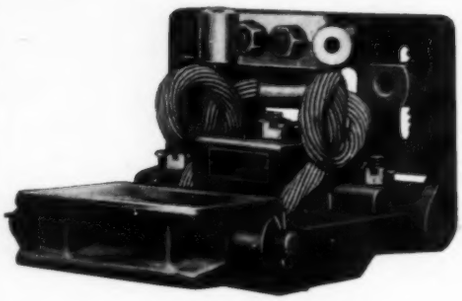
provides the constant contact that insures reliable transmission of power to your cranes, conveyors and other electrical industrial hoisting and hauling systems.

A complete line utilizing either rails, angles or wire as conductors and including numerous types of insulators for either under-running or over-running operation. You may also select from many types of current collectors including Junior, Universal and Pantagraph styles and contact rail shoes.

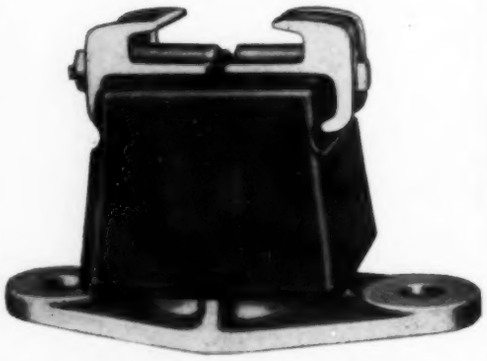


WRITE FOR CATALOG

These products are widely used in most large steel mills, being thoroughly proved in service. The complete catalog illustrated below will be very helpful to all interested in the construction or maintenance of cranes or feeder systems.



Typical Keystone Reversible Contact Rail Shoe



Typical Keystone Contact Rail Insulator for supporting and insulating standard Tee Rail

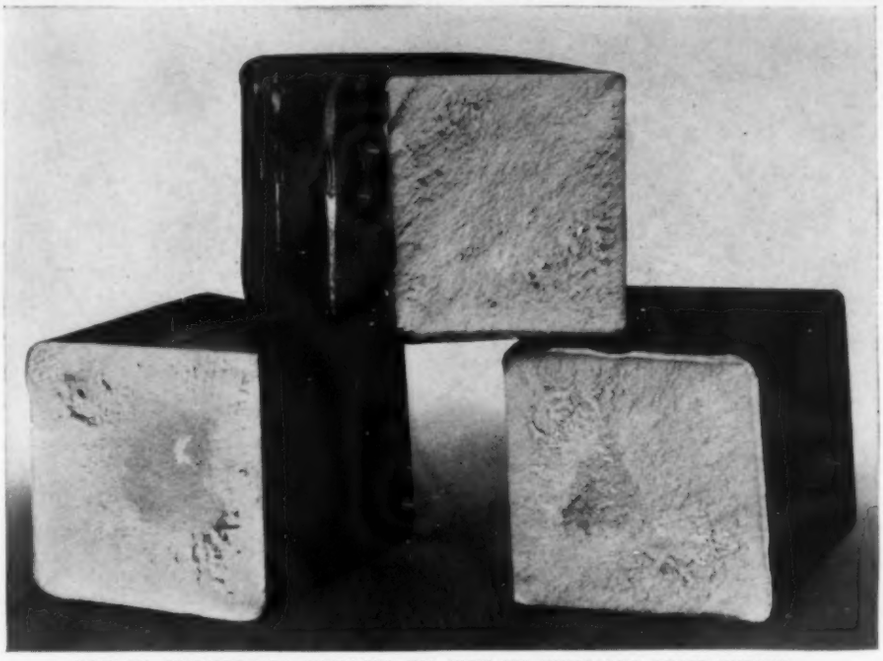
ELECTRIC SERVICE MANUFACTURING CO.

Former Name—Electric Service Supplies Co.

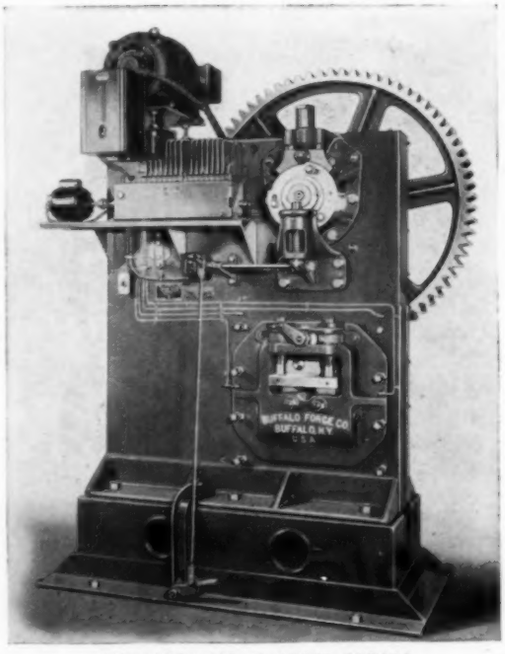
17th & CAMBRIA STREETS • PHILADELPHIA 32 • PA. • Branches in Principal Cities

FOR LOWER MANUFACTURING COSTS

SHEAR BILLETS LIKE THIS



SQUARE, UNDISTORTED SURFACES ON CUTS BY "BUFFALO" BILLET SHEARS — NOTE LACK OF "SMEARING"



"BUFFALO" NO. 9 BILLET SHEARS

ACCURATE, FAST CUTTING-UP TO

10" ROUNDS!

— or 9" squares. And "Buffalo" Billet Shears are available in 11 standard sizes to handle from 2" square stock on up.

AND THEIR SPEED PILES UP SHOP ECONOMIES! As an example of this, the No. 12 Buffalo Billet Shears cut SIXTEEN 5" round billets every minute.

If you want to cut billets at the lowest cost—with cleaner, squarer surfaces—you'll do it with "Buffalo" Billet Shears. *Just write us for the details.*

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO 4, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

MACHINE TOOLS by "Buffalo"

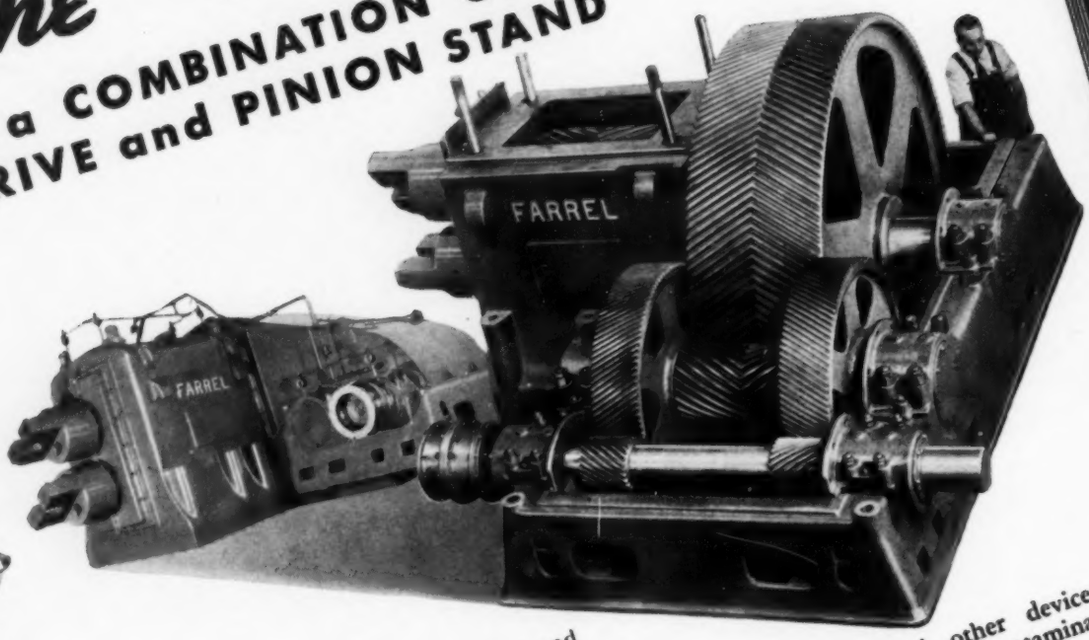
- BACK SPOT FACERS
- BAR CUTTERS
- BENDING ROLLS
- BILLET SHEARS
- DOUBLE END PUNCHES AND SHEARS
- LOCOMOTIVE SHEARS
- MILL TYPE SHEARS
- RAPID ACTING PUNCHES
- SINGLE END SHEARS
- SPRUE CUTTERS
- STRUCTURAL IRON WORKERS
- UNIVERSAL IRON WORKERS
- DRILLS FOR THE PRODUCTION LINE DRILLS FOR THE TOOL ROOM

CONTINUOUS SERVICE—FASTER OPERATION—PEAK ACCURACY

Here is...

The "Under-Cover" Story

of a COMBINATION GEAR DRIVE and PINION STAND



This is the main gear of the 1,250 HP drive illustrated at the right. It has Farrel-Sykes continuous herringbone teeth, is 10′ 7″ in diameter, 36″ face, and weighs over 13 tons.

This is the story of gears and pinions and the other "undercover" parts which make a rolling mill drive give a lifetime of satisfactory operation.

The drive illustrated is a combination reduction unit and pinion stand designed to transmit 1,250 HP to a 26-inch two-high mill. The first reduction consists of split (divided) double helical gears, and the second reduction gears and the mill pinions are the Farrel-Sykes continuous tooth herringbone type, a compact gear arrangement which distributes the load uniformly and requires minimum floor space.

With all shafts mounted in roller bearings, friction losses are reduced to a minimum, and efficient operation is further assured by effective lubrication. The main gears are dip-and-splash lubricated from a reservoir of extra large capacity, and the other gears and mill pinions and bearings are force-feed lubricated by separate pump. Automatically self-cleaning oil filters and other devices protect the drive against oil contamination or circulation failure. Housed in a heavy Meehanite case, with welded steel cover for the gear unit, maintenance of correct alignment of gears and pinions is made certain.

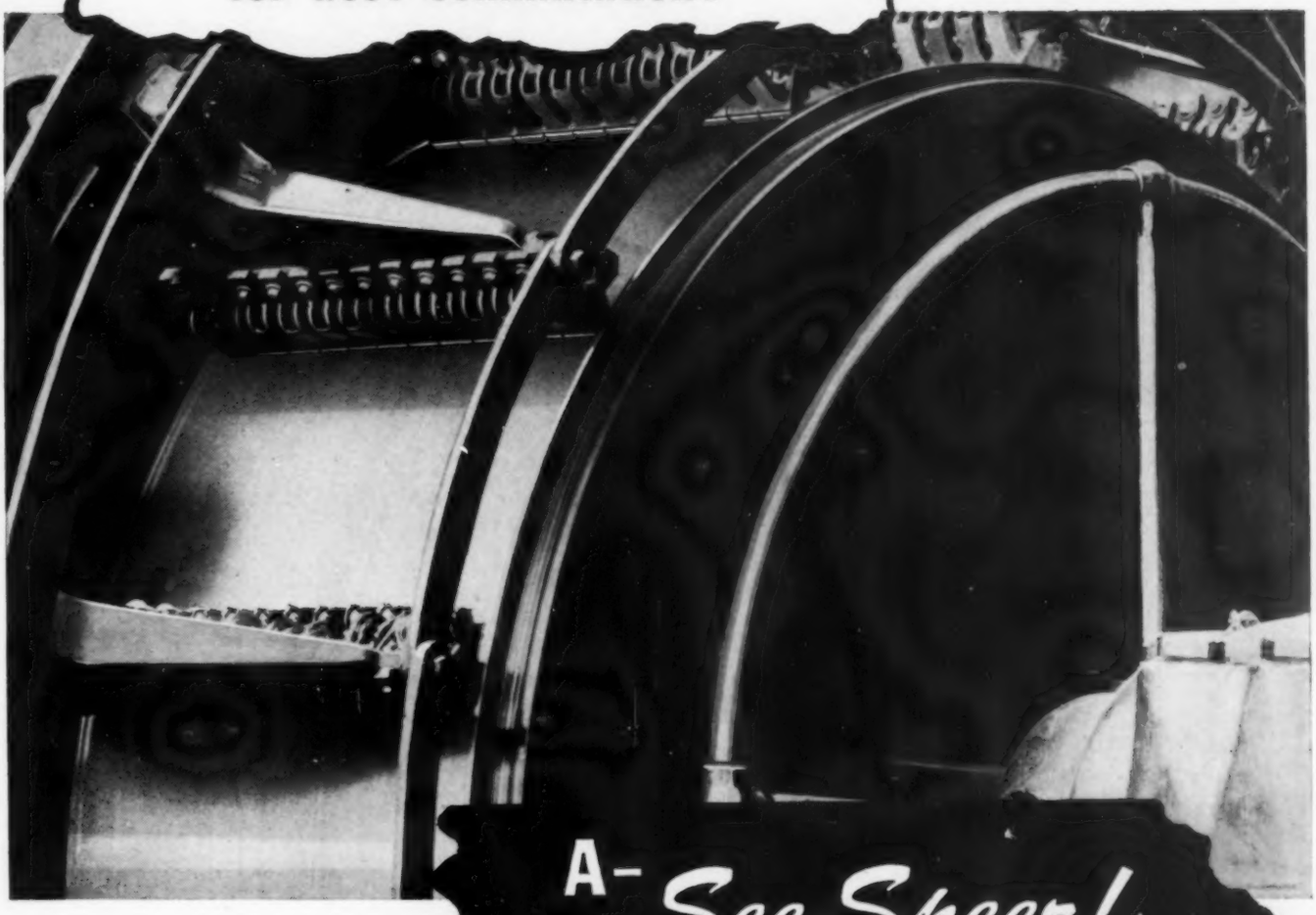
Designed to suit individual requirements, Farrel rolling mill drives and pinion stands—separate or combination units — are available in any capacity. Farrel engineers will be glad to supply full information for any specific application.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.
Plants: Ansonia, Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Chicago, Los Angeles

FB-123-A

Farrel-Birmingham

Q-what brush angle for best commutation?



A- See Speer!

Firm contact between brush and commutator is important for best brush performance . . . and the effectiveness of this contact is largely determined by brush angle.

In designing new machines or ridding present equipment of "bugs" in brush operation, consideration must be given to spring tension, pressure of brush holder against side of the brush face and frictional pull—all help influence the brush angle.

Speer engineers, with extensive knowledge of brushes and experience in their use, can analyze these factors for you and determine the best conditions as well as the proper brush for your motors and generators. Take advantage of this Speer service whenever you have a question on brush applications and performance.

Speer

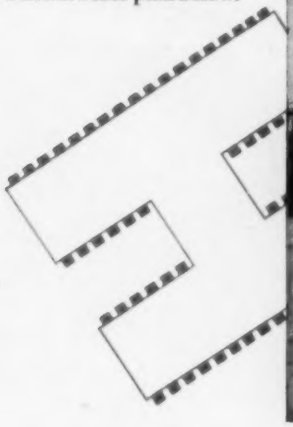
CARBON COMPANY
ST. MARYS, PENNA.

brushes • contacts • welding electrodes • graphite anodes • rheostat discs • packing rings • carbon parts

CHICAGO • CLEVELAND • DETROIT • MILWAUKEE • NEW YORK • PITTSBURGH

PART OF A BATTERY OF STAYNEW INTAKE FILTERS HANDLING MORE THAN 300,000 C.F.M.

THE WORLD'S LARGEST DIESEL POWER PLANT, *completely equipped* with 50 DS-6000 Staynew Filters. Floor plan below.



THE EFFICIENCY OF STAYNEW

DRY-TYPE INTAKE FILTERS

ACTUALLY INCREASES WITH USE

WHY allow rigid intake filter cleaning schedules to slow production? Equip all engines and compressors with Staynew Dry-type Filters. These famous Radial Finned filters frequently operate *two or more years* without attention. Yet, because any dust that accumulates on the Radial Fins acts as a pre-coat or filter-aid, their efficiency is even greater after considerable use than when first installed.

Increase of back pressure is negligible, due to the initial low resistance (approx. ½" W.G. as rated) and the recognized ability of this type filter to shake off an excessive accumulation of dust.

When cleaning *is* required, it's a cinch! Just vacuum or wash—the work of a few minutes only. There are no oil reservoirs, no moving parts.

DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

COMPLETE DETAILS ON REQUEST

DOLLINGER CORPORATION

16 CENTRE PK., ROCHESTER 3, N. Y.

REPRESENTATIVES IN PRINCIPAL CITIES

Model IDR: ALL the convenience of ground level installation plus the advantage of high level air intake. An exclusive design.

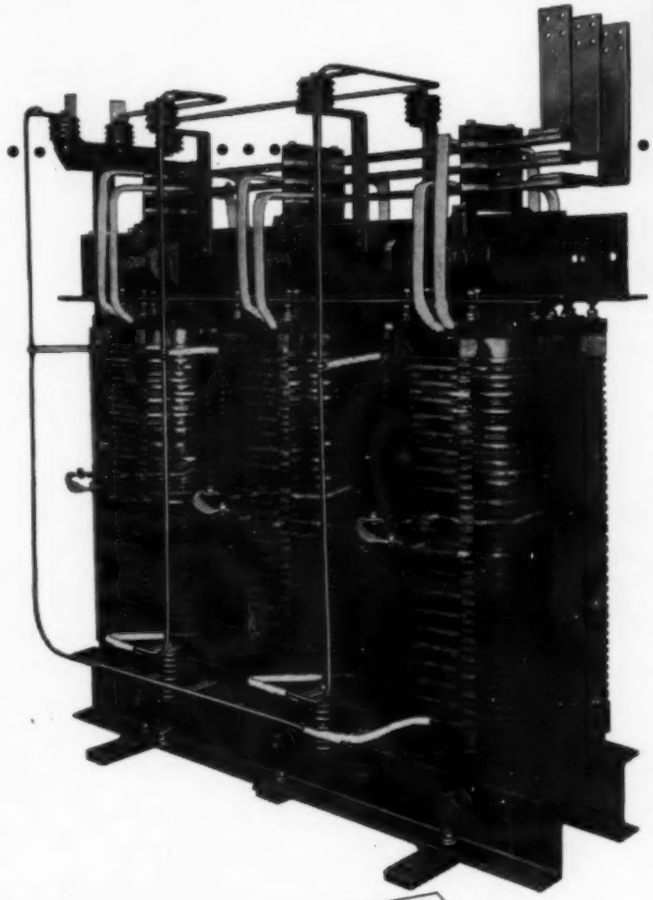
Model D: The standard intake filter for heavy duty service on large engines and compressors.

Model DS: Similar to the Model D with the addition of silencing tubes.

Wagner Dry-Type Indoor Transformers

Now available in ratings from 100 to 2000 kva

To meet industry's growing need for larger indoor dry-type load center transformers, Wagner has broadened its line of three-phase dry-type transformers to include ratings up to 2000-kva in the 15-kv class and below. Especially developed for plant power distribution circuits, these units are compactly housed in neat, attractive enclosures, which can be arranged to include primary and secondary switchgear compartments to form readily accessible, closely-coupled unit substations. Complete enclosure of all equipment protects against accidental contact with live parts. Relatively light in weight, so that they can be used in multi-story buildings, they are readily adaptable to any installation requirement.



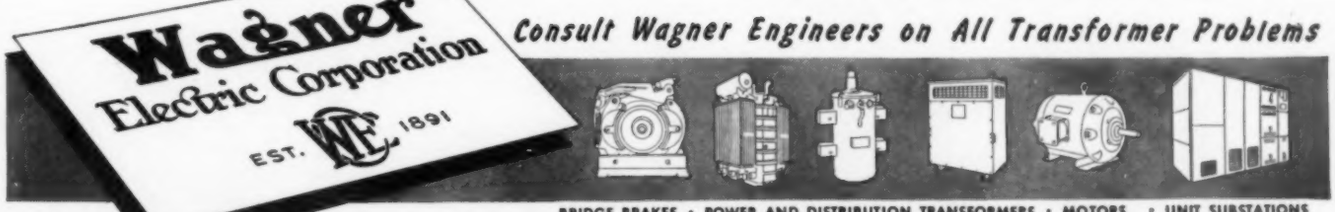
More than fifty years of transformer building experience has been incorporated in the design and construction of these transformers. The coil conductors are insulated with double servings of fiber glass. The windings are insulated from each other and from the core and mechanical parts using Class B and Class C materials, the latter being employed where extra strength is required. The core is sturdily constructed, and both the core and the coil stacks are provided with vertical ducts for effective cooling. The entire core and coil assembly is given successive baked coats of heat resistant synthetic varnish which produces a tough, high gloss finish. The connections between phases and to the switch gear are securely braced and well insulated from each other and from ground, and the conducting surfaces of all clamped joints are silver plated to prevent corrosion.

Transformers can be furnished with equipment for indicating winding temperature. Fans for increasing the capacity 25% may also be provided when the possibility of load growth warrants this addition.

Bulletin TU-56 describes in detail the transformers, the enclosures, the various types of incoming line sections available, and the optional equipment and accessories that can be furnished. Write for your copy today.

Wagner Electric Corporation
6483 PLYMOUTH AVE., ST. LOUIS 14, MO., U. S. A.

Consult Wagner Engineers on All Transformer Problems



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T48-3A

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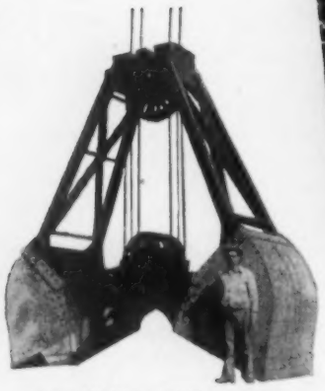
Wellman Ore and Coal Handling Bridges

For fast and efficient action

One of two 6-ton Coal Handling Bridges in this installation.



6-ton Wellman Williams Type Coal Bucket used with these bridges.

• Take advantage of Wellman's long experience in designing and building handling bridges in many types and capacities. Your selection from the complete line will provide fast and efficient handling of coal or ore.

THE WELLMAN ENGINEERING COMPANY

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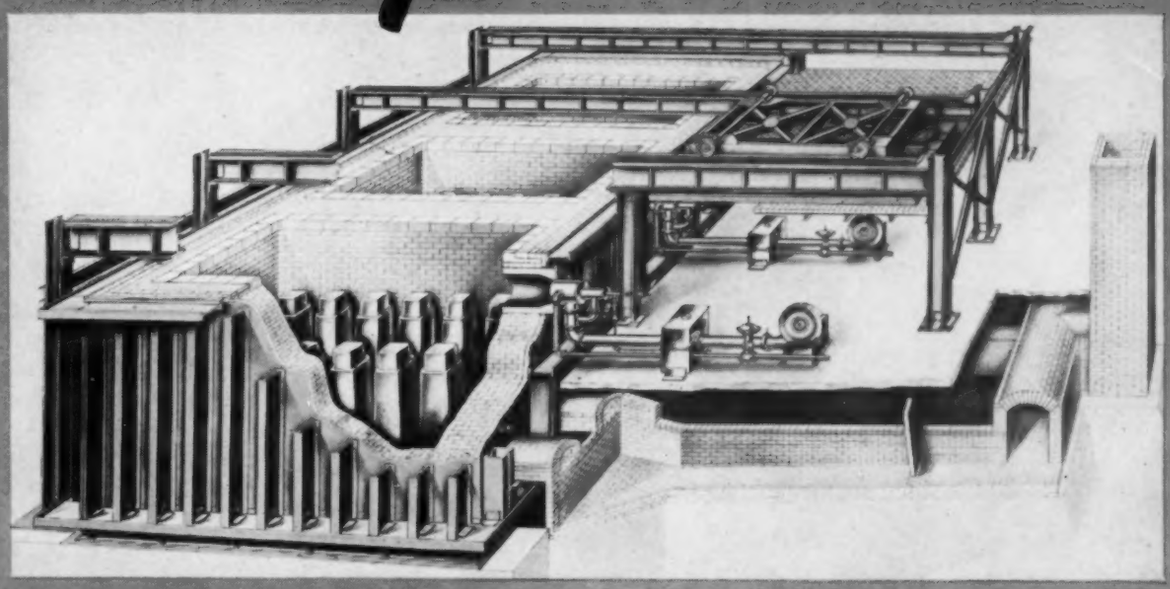

The Urquhart Combustion Process for Heating Furnaces, Soaking Pits, and Forge Furnaces

AN INSTALLATION of the Urquhart Combustion Process on Soaking Pits has shown a definite saving in construction cost, floor space, fuel, scale loss and maintenance, with uniform heating and greater yield. Bottoms were cleaned for the first time after twenty-one weeks of continuous operation.

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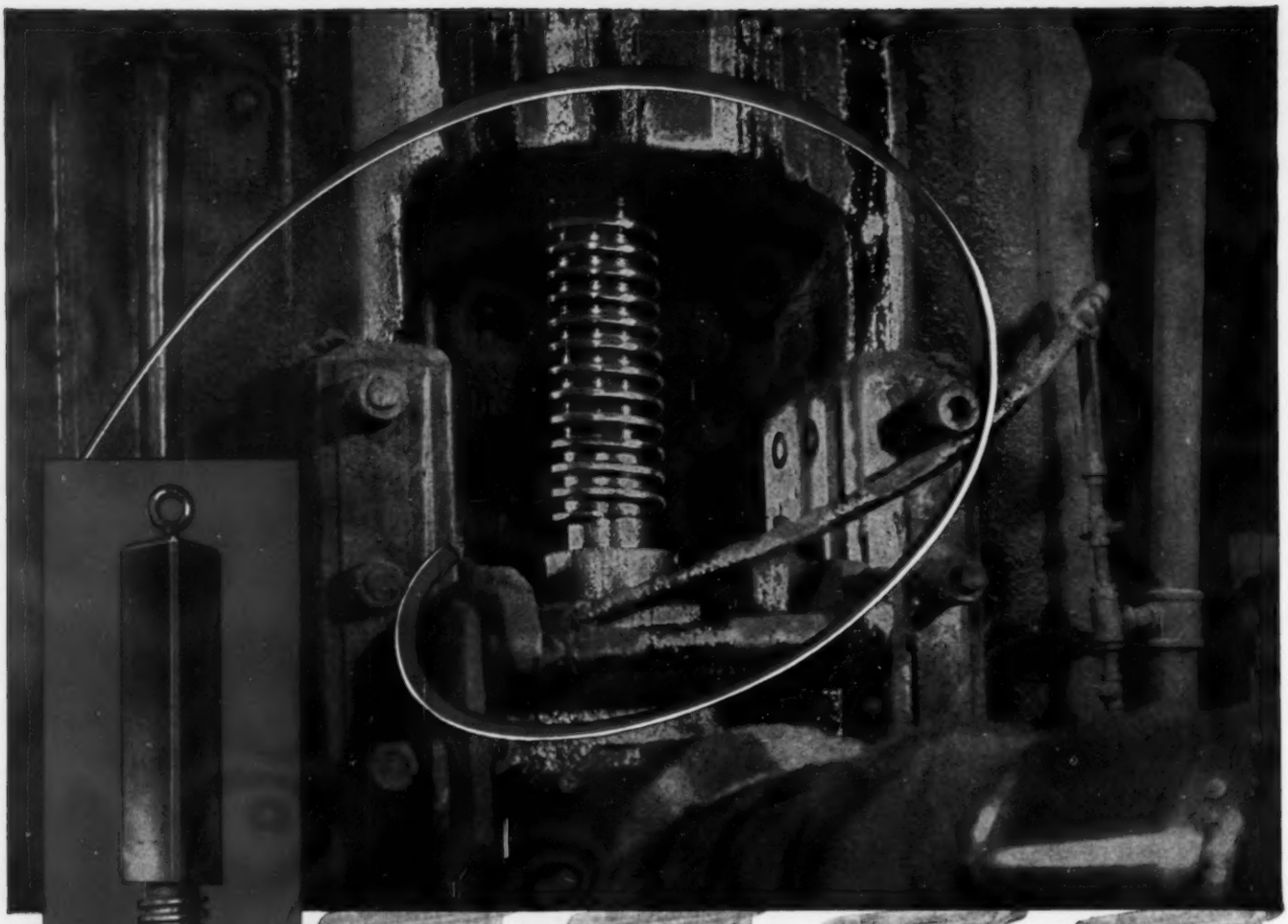

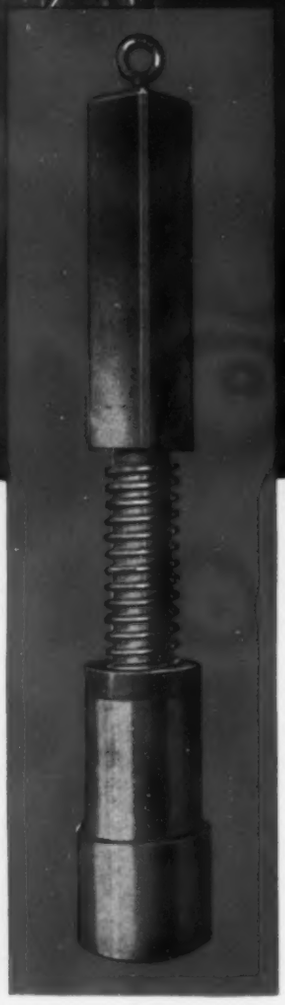

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Installed on Coke Quench Car

This is the first of a series of 16 installations of Lintern Aire-Rectifiers purchased by one of the country's largest steel companies for use on quench cars, larry cars, coke pushers and door cranes.

It is the first installation of its kind anywhere. The fully enclosed cab replaces the old open cab with its hazards of steam, gas, and hot coke . . . results in safety for men and equipment, and assures better and greater production.

The Aire-Rectifier provides normal temperature in the cab of 80° to 85°, protecting the operator against the high temperatures (running up to 130°), and providing clean, healthful air with the coke dust, steam and SO_2 filtered out.

These Aire-Rectifiers are the only ones specifically engineered for all steel mill and foundry applications, and which cover all requirements with standard models. They are the only make universally used the country over, in all types of industrial applications, the result of long specialization in hot metal cab conditioning.

Write for Bulletin AC-111546.

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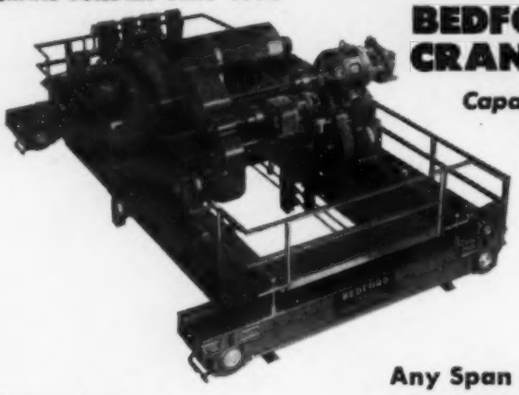

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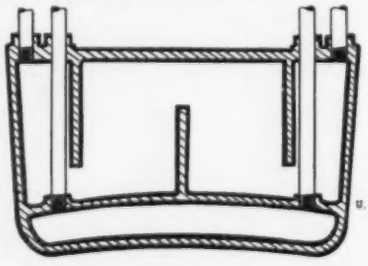
A QUICK LOOK
At the Advantages of the
DOBSCHA DOUBLE COMPARTMENT COOLING PLATE



U. S. PAT. NO. 2,311,819.

A GLANCE at the accompanying illustration will reveal the two prime advantages of the Dobscha Cooling Plate:

1 The "NOSE" compartment may be sealed off, in event of "burning," without reducing the cooling area of the large volume "BUTT" compartment.

2 Direct feed and discharge affords high velocity water travel through the nose, eliminating clogging due to bad water sediment.

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● Falcon casts the Dobscha Plate vertically, without anchors or chaplets, "NOSE" down, so the densest metal is in the "NOSE" where needed.

Falcon installs the copper "Feed" and "Discharge" pipes to the nose compartment.

Falcon ships each Dobscha Plate in a special crate or cradle which protects these nose "Feed" and "Discharge" pipes in shipping and handling between the foundry and your furnace wall.

Falcon is licensed to make and sell the Dobscha Plate. U. S. Pat. 2,311,819.

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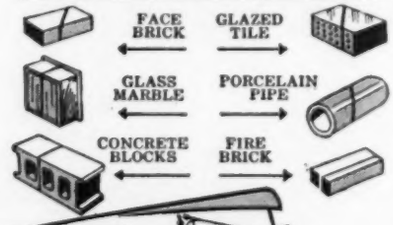

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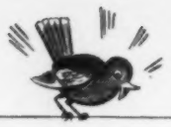
Time for a



Spring Check-up . . .

on the plan that delivers Peace of Mind

THANKS to the work of patriotic volunteers, the U. S. Savings Bonds program has carried America a long way up the road to economic security.

During 1946, in spite of all the problems and uncertainties the nation faced, sales of Savings Bonds *exceeded redemptions* by $1,389,216,000. The success of this great sales operation has helped stem the tide of inflation, has reduced public debt holdings of the banking system, and has given millions of citizens a stake in their country and a profitable investment in their own futures.

Yes, we've come a long way—but the trip isn't over! Now is the time to check up on your Payroll Savings Plan. Make sure that all your new employees are familiar with its advantages. Remind *all* your employees that there's no easier, surer way to build their own futures—and America's—than by buying Bonds regularly through the Payroll Savings Plan. Every $3 invested pays $4 at maturity!

For any help you need in conducting the Payroll Plan, call on your State Director of the Treasury Department's Savings Bonds Division.

New Savings Bonds Plan won't affect the P.S.P.

SOON the Treasury Department and the banks of America will make it possible for farmers, doctors, and other self-employed people to participate in "automatic" Bond buying by special arrangement with their banks. This extension of the Savings Bonds program is not a partial payment plan and is intended *only* for people who are not in a position to take advantage of the Payroll Savings Plan.

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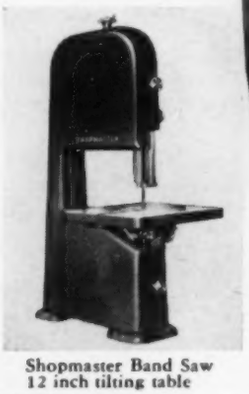
Bearings

HELP

KEEP SHOPMASTER TOOLS

SMOOTH RUNNING

Shopmaster Drill Press
12 inch ½ inch chuck



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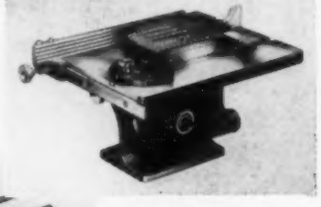

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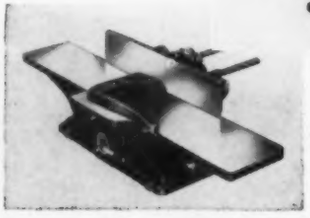

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To maintain accuracy, rigidity, speed and dependability, **Shopmaster Inc., Minneapolis, Minn.,** employs *Norma-Hoffmann Precision Bearings* exclusively in its line of high quality "Shopmaster Tools" — a few of which are illustrated here. The reason, Shopmaster Engineers know from experience that Norma-Hoffmann Precision Bearings contribute to the performance of the machines . . . give years of trouble-free operation with minimum maintenance.

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A million more tons on composition bearings with Farval

FARVAL—*Studies in Centralized Lubrication No. 100*

A LARGE steel mill in the Pittsburgh district reports that the best tonnage obtained from a composition bearing on a 40-inch blooming mill when lubricated with river water only, was approximately 379,000 tons.

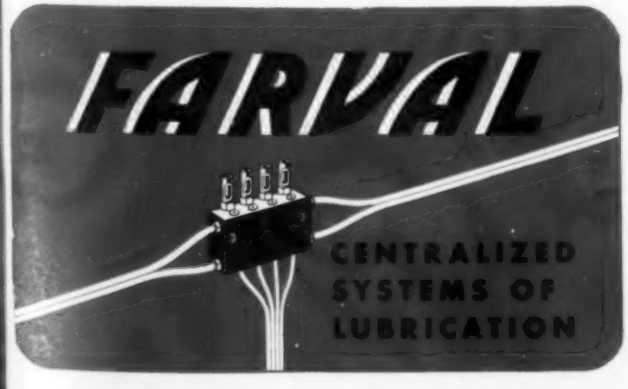
By installing Farval Centralized Grease Lubrication and using good city water, the mill was able to obtain 1,372,997 tons before the bearings wore sufficiently to require replacement . . . an increase of almost one million tons. The Farval system delivered a measured quantity of grease to the bearings every 12 minutes.

The illustration at the right shows the Farval-lubricated composition bearing which was removed from the top roll neck on the pressure end of the mill after it had rolled the 1,372,997 tons.

Farval delivers oil or grease under pressure to a group of bearings from one central station, in exact quantities, while a machine is in operation. Farval is the Dualine System with the Positive Piston Displacement Valve. This valve has but two moving parts and is fully adjustable, with a Tell-tale indicator at each bearing to show the job is done. For a full description of Farval, write for Bulletin 25. The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

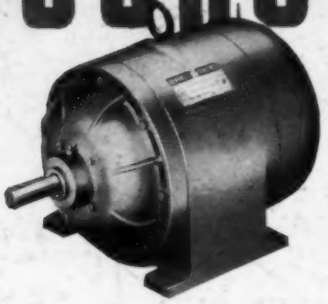
Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited

Farval-lubricated composition bearing after it had rolled 1,372,997 tons.



5 BILLION MOTOR HOURS

PROVE YOU CAN'T BEAT



TRI CLAD

EXTRA PROTECTION

Announcement of the Tri-Clad motor, back in 1940, ushered in a new concept of general-purpose motor design. Substantially increased horsepower-per-frame-size was one feature. Smarter appearance was another. But what really sold more than a million Tri-Clad motors is the *extra protection* we built into them. Figured conservatively, they have delivered more than 5 billion hours of service.

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Windings of Formex* wire, together with improved insulating materials, reduce the chances of electrical failure. Heat is dissipated quickly —motor stays young for years and years.

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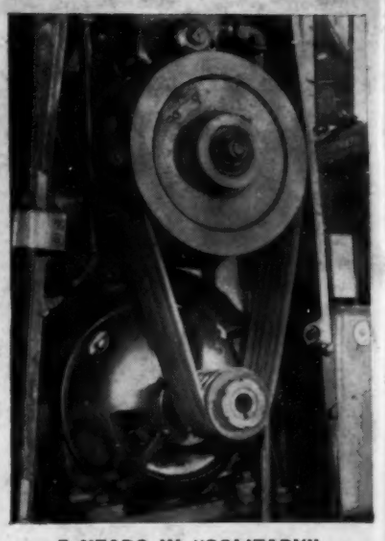

5 YEARS IN "SOLITARY"
Many machine tools in the Bell Aircraft plant at Buffalo have pioneer Tri-Clad motors tucked away inside. The result is a sleek exterior for the machine and valuable floor space saved. During the war, when time was short and uninterrupted protection was of utmost importance, these motors gave dependable service, demanding only a minimum of maintenance and inspection. The Tri-Clad motor you see here driving a milling machine has not been removed for five years. It has done its job faithfully despite the strain of a 3-shift, 7-day work schedule, and along with 200 other Tri-Clad motors in the Bell plant, gives every sign of staying on the job indefinitely.

NOW—PEAK MOTOR TOUGHNESS
The Tri-Clad totally enclosed, fan-cooled motor is designed for use in adverse atmospheres — in iron dust, out-of-doors, in hazardous areas, and chemical atmospheres. It gives you these important construction features:

- A cast-iron, double-wall frame which completely encloses and protects windings and punchings.
- A nonshrinking compound around motor leads which protects motor interior from dust and moisture.
- A rotating labyrinth seal which further protects the motor interior from damage by foreign matter.

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